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ANNOUNCEMENT

We record with deep sorrow the passing away of Dr. M. G. Jotwani, who has been doing great service to *Entomon* as Member of the Editorial Board of the Journal, on 4th June 1983.

Managing Editor
Entomon

(See Obituary, P. 199)

THE THIRD ORIENTAL ENTOMOLOGY SYMPOSIUM

The Third Oriental Entomology Symposium is rescheduled for 21–24 February 1984. Broad fields of the symposium include: Biosystematics & Zoogeography, Ecology & Behaviour, Physiology, Agricultural & Forest Entomology, Cytology & Cytogenetics and Medical & Veterinary Entomology. Dr. N. R. Prabhoo, Department of Zoology, University of Kerala, Kariavattom, Trivandrum 695 581 will be the Convener of the Symposium, who may please be contacted for further details.

Forthcoming Book

“A Catalogue of the Araneae described between 1940 and 1981” by Prof. P. M. Brignoli, Manchester University Press, Dover, New Hampshire, U.S.A., \$ 90.

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KARYOLOGY OF FOUR SPECIES OF GALL-FORMING APHIDS (HOMOPTERA : APHIDIDAE) FROM THE GARHWAL HIMALAYS

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(Received 28 February 1983)

Four species of gall-forming aphids, namely, *Epipemphigus imaicus*, *Amphicercidus lonicerae*, *Myzus sorbi* and *Dysaphis (Pomaphis) pavlovskyana*, collected from different host plants in and around Jamunetri, Garhwal Himalays, India, have been studied cytologically for the number and morphometrical analysis of somatic chromosomes in their embryos. While *E. imaicus* and *A. lonicerae* had the same diploid number of 18, both *M. sorbi* and *D. (P.) pavlovskyana* had $2n = 12$ chromosomes.

(Key words: cytotaxonomy, gall-aphids, chromosomes, embryos, viviparous females)

INTRODUCTION

Among the four species under study, *Epipemphigus imaicus* is a true leaf-gall forming aphid belonging to the sub-tribe Pemphigina, tribe Pemphigini, sub-family Pemphiginae under the family Aphididae, while the three others, namely, *Amphicercidus lonicerae*, *Myzus sorbi* and *Dysaphis (Pomaphis) pavlovskyana*, produce pseudo-galls on leaf-margins and belong to the sub-tribe Macrosiphini, tribe Aphidini, sub-family Aphidina under the family Aphididae. So far as we are aware, all these species except *E. imaicus* (KHUDA-BUKSH, 1980) are being cytologically investigated for the first time.

MATERIALS AND METHODS

Apterous viviparous females of *Epipemphigus imaicus* (Choldkovsky), *Amphicercidus lonicerae* Maity and Chakraborti, *Myzus sorbi* Bhattacharya and Chakraborti and *Dysaphis (Pomaphis) pavlovskyana* were collected in and around Jamunetri, Garhwal Himalayas, India, from the host plants *Populus* sp. (Salicaceae), *Lonicera quinquelocularis* (Caprifoliaceae), *Sorbus* sp. (Rosaceae), and *Pyrus linaia* (Rosaceae) respectively and their young embryos were subjected

to the citrate-air during Giemsa stain schedule for the preparation of slides for cytological examination. The diploid number in each species has been determined from at least 50 well-spread metaphase complements. Each chromosome of a complement was measured and identical ones were matched as homologous pairs. The relative percentage lengths (R_L) of each pair in the complement were obtained from the mean values of ten complements (Table 1) and the idiograms of each species (Figs. 5-8) were prepared on the basis of their relative percentage lengths.

RESULTS

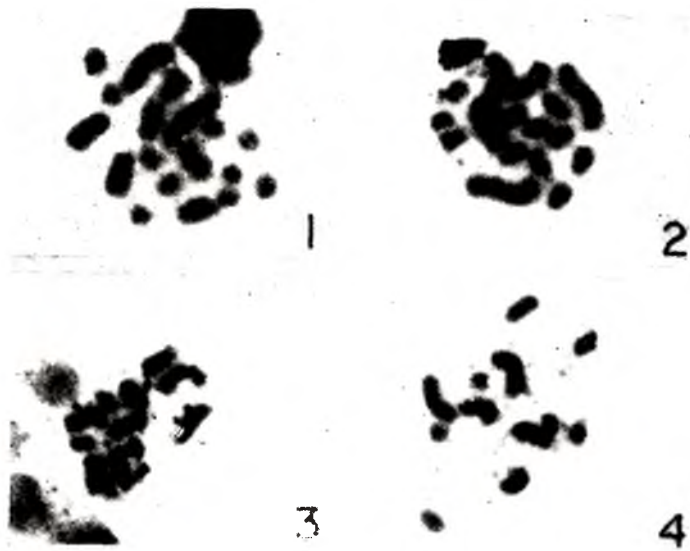
The mitotic behaviour in all the four species of aphids followed the orthodox holokinetic pattern as described for some other species of aphids earlier (KHUDA-BUKSH, 1980; DATTA & KHUDA-BUKSH, 1980; KHUDA-BUKSH & DATTA 1978; KHUDA-BUKSH & PAL, 1981, 1983).

The typical diploid metaphase complements in both *E. imaicus* (Fig. 1) and *A. lonicerae* (Fig. 2) contained 18 chromosomes while those in *M. sorbi* (Fig. 3) and *D. (P.) pavlovskyana* (Fig. 4) had 12

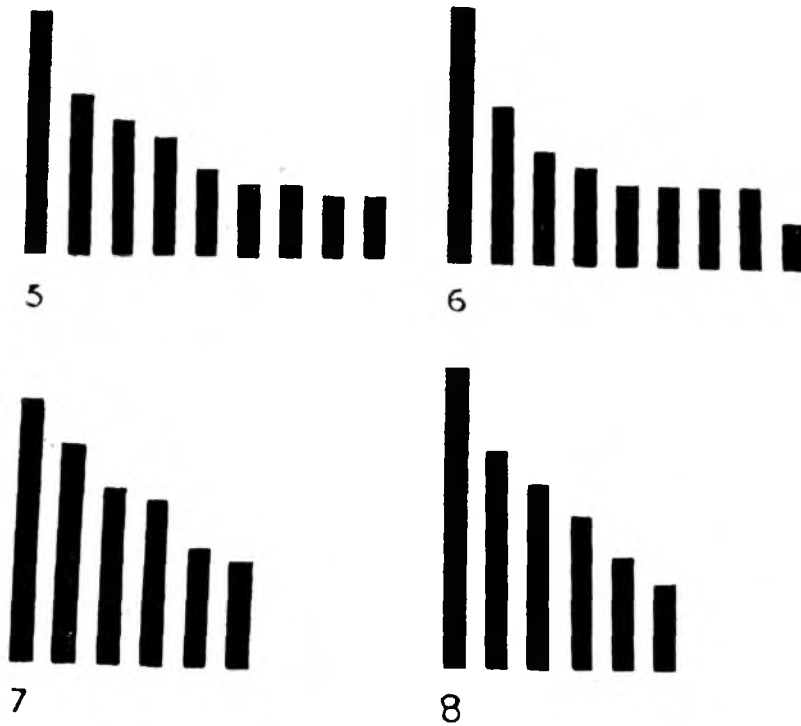
TABLE 1. Mean lengths and relative percentage lengths (RL) of chromosomes expressed as haploid set
E. imitatus, *A. loniceræ*, *M. sorbi* and *D. (P.) pavlovskyana*.

Sl. Chrom. No.	<i>E. imitatus</i>				<i>A. loniceræ</i>				<i>M. sorbi</i>				<i>D. (P.) pavlovskyana</i>			
	Mean length (μ m)	SD	SE	RL	Mean length (μ m)	SD	SE	RL	Mean length (μ m)	SD	SE	RL	Mean length (μ m)	SD	SE	RL
1.	7.30	± 0.385	0.272	23.61	7.20	± 0.951	0.672	25.70	5.36	± 0.820	0.289	24.66	5.99	± 0.922	0.499	28.61
2.	4.80	± 0.195	0.137	15.52	4.37	± 0.240	0.169	15.60	4.56	± 0.677	0.239	20.98	4.33	± 0.880	0.332	20.68
3.	4.13	± 0.100	0.070	13.36	3.12	± 0.050	0.035	11.13	3.66	± 0.575	0.203	16.84	3.66	± 0.692	0.261	17.48
4.	3.55	± 0.095	0.067	11.48	2.78	± 0.095	0.067	9.92	3.43	± 0.634	0.224	15.78	3.03	± 0.735	0.278	14.47
5.	2.69	± 0.0	0.0	8.70	2.30	± 0.0	0.0	8.21	2.49	± 0.560	0.198	11.45	2.21	± 0.369	0.139	10.55
6.	2.30	± 0.0	0.0	7.44	2.30	± 0.0	0.0	8.21	2.23	± 0.652	0.230	10.26	1.71	± 0.364	0.137	8.17
7.	2.30	± 0.0	0.0	7.44	2.30	± 0.0	0.0	8.21	—	—	—	—	—	—	—	—
8.	1.92	± 0.0	0.0	6.21	2.30	± 0.0	0.0	8.21	—	—	—	—	—	—	—	—
9.	1.92	± 0.0	0.0	6.21	1.34	± 0.190	0.834	4.78	—	—	—	—	—	—	—	—

SD = Standard Deviation; SE = Standard Error.



Figs. 1—4. Metaphase complements of *E. imaicus* (Fig. 1), *A. loniceræ* (Fig. 2.), *M. sorbi* (Fig. 3) and *D. (P.) pavlovskyana*. ($\times 1500$ approx.)



Figs. 5—8. Idiograms based on relative percentage lengths. *E. imaicus* (Fig. 5), *A. loniceræ* (Fig. 6), *M. sorbi* (Fig. 7) and *D. (P.) pavlovskyana* (Fig. 8).

chromosomes each. In all the species, the chromosomes were more or less gradually seriated (Figs. 5-8) except for the appreciable size difference between the 1st and 2nd pairs in all but *M. sorbi* (Fig. 7). There was also some noticeable size-difference between the 8th and 9th pairs in *A. lonicerae* (Fig. 6). The chromosomes from the longest to the shortest one measured between 7.30 and 1.92 μm in *E. imaicus*, between 7.20 and 1.34 μm in *A. lonicerae*, between 5.36 and 2.23 μm in *M. sorbi* and between 5.99 and 1.71 μm in *D. (P.) pavlovskyana* (Table 1). A comparison of the idiograms (Figs. 5-6) would reveal their general karyotypic similarity except for the minor differences in size of their individual chromosomes, particularly the 9th pair, which were smaller than their counterparts in *E. imaicus*. Correspondingly, the idiograms of *M. sorbi* and *D. (P.) pavlovskyana* (Figs. 7-8) were very close to each other except for the larger size of the 1st pair and smaller size of the 4th pair in *D. (P.) pavlovskyana* as compared to their counterparts in *M. sorbi*.

DISCUSSION

Out of nearly 700 species of aphids taxonomically recorded in India (GHOSH, 1979), cytological investigations have so far been carried out on some 70 odd species (DATTA & KHUDA-BUKHSH, 1980; KHUDA-BUKHSH, 1979, 1980; KHUDA-BUKHSH & PAL, 1983; KULKARNI & KACKER, 1979, 1980, 1981 a, b; KURL, 1978, 1980 a, b, 1981; PAL & KHUDA-BUKHSH, 1980, 1982) while similar studies on the gall-forming species from India appear to be lacking so far except an earlier report by one of us (KHUDA-BUKHSH, 1980). *E. imaicus* collected from Mussoorie was also reported there to have $2n = 18$ chromosomes in agreement to

the present findings. In detailed comparison of the morphometrical data on chromosomes of *E. imaicus* collected from two different regions of the Garhwal Himalayas, the lengths of individual chromosomes differed to some extent. This was more apparent in respect of the 1st pair which appeared smaller in the Mussoorie population than that of the Jamunetri population. This difference might also originate due to the difference of techniques employed in the two studies if the difference was not an inherent one in the two populations. A more critical check is needed before any conclusion could be drawn.

From the present study it seemed that there was no chromosomal relationship with regard to the habitat of the gall-forming aphids because the true gall-forming species, *E. imaicus*, had $2n = 18$ while the three other pseudogall forming ones had diploid numbers of 18 and 12 as stated before.

Acknowledgements: The authors are grateful to Prof. G. K. MANNA, and to Prof. S. P. BHATTACHARYYA, Head, Department of Zoology, Kalyani University for encouragements and laboratory facilities. Sincere thanks are due to Dr. D. RAY-CHOUDHURY, and to Dr. S. CHAKRABORTI, of the Department of Zoology, Calcutta and Kalyani University respectively, for identification of the aphid specimens. Financial assistance from the UGC, Govt. of India, for the work is gratefully acknowledged.

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POPULATION DYNAMICS IN RELATION TO BREEDING OF THE WASP *SPELIPHRON VIOLACEUM* AND ITS PARASITOID *MELITTOBIA* SP¹

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(Received 15 January 1982)

Covering 665 holes of unused electrical sockets, population dynamics of the predatory wasp *Speliphron violaceum* and its parasitoid *Melittobia* was studied between 1977 and 1979. From estimates of the mean number and weight of spiders packed in a hole during different months, biomass of prey exploited was calculated. Number of larvae deposited by *S. violaceum* was directly proportional to the biomass of prey captured. Incidence of larviposition by the wasp was higher during the monsoon than during summer and was dependent on prey availability. In 1977–1978, the prey-predator-parasitoid system lost about 28,300 spiders and produced 823 and 43,350 *S. violaceum* and *Melittobia* respectively. Corresponding figures for 1978–1979 were 23,500 spiders, 830 *S. violaceum* and 28,850 *Melittobia*. Fecundity of the wasp (oocytes/female) was significantly related to the weight of females. Search power of the parasitoid averaged 5.02×10^{-4} and was found to be very low compared to other hymenopterous parasitoids. The low search power of the parasitoid was responsible for the low incidence of *Melittobia* infection which averaged 22.8%.

(Key words: *Speliphron violaceum*, *Melittobia*, population dynamics, prey exploitation, search power, incidence of infection)

INTRODUCTION

In terms of abundance and species diversity, predatory and parasitic insects are considered less important than herbivorous insects. Yet by virtue of their trophic status and their potential to regulate populations of other insects, they play a key role in community ecology. Parasitic insects are a special form of predators and both require a host/prey species to complete part or whole of their life cycle (see VARLEY *et al.*, 1973; HASSELL, 1978). Whereas the success of a predator de-

pends on the number of prey killed for consumption, that of the parasite depends on the number of hosts it seeks for oviposition and propagation of progeny (HOLLING, 1959). As a definite number of progeny emerges from each host attacked, the rate of increase of the parasite population is linearly related to the number of hosts attacked (HASSELL & MAY, 1973). However, the increase of predator population has a complex relation to the number of prey attacked and consumed and depends considerably on the mortality at different life stages of development and fecundity (LAWTON *et al.*, 1975; BEDDINGTON *et al.*, 1976; see also MUTHUKRISHNAN & PANDIAN, 1983). The wasp *Speliphron violaceum* is a special type of predator, as the females

¹ Paper presented at the conference of the International Society of Invertebrate Reproduction held in the University of Newcastle, England.

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capture the prey exclusively during the adult stage only, to provide for their larvae. Infection by the parasitoid *Melittobia* is the only major factor causing mortality of *S. violaceum*. The present paper deals with the population dynamics of *S. violaceum* and its parasitoid *Melittobia* in relation to their breeding.

MATERIALS AND METHODS

S. violaceum larviposits on its prey (spider) and places the larva along with the prey in the holes of electrical sockets. After provisioning the cell with paralysed spiders, the female seals the hole with sand grains. Preliminary observations on the quality of prey packed inside 25 holes during different months revealed that the web spinning spiders *Argiope pulchella*, *Cyrtophora cicatrosa* and *C. citricola* constitute the dominant prey species of the developing wasp. A few larvae with the spiders deposited were transferred from the holes into separate vials and the development was carefully followed. The larva feeds on the spiders, completes larval development in 6 ± 2 days and undertakes pupation, which lasts for 16 ± 2 days (Fig. 1). In total the larva completes development and metamorphoses within 22 days following larviposition.

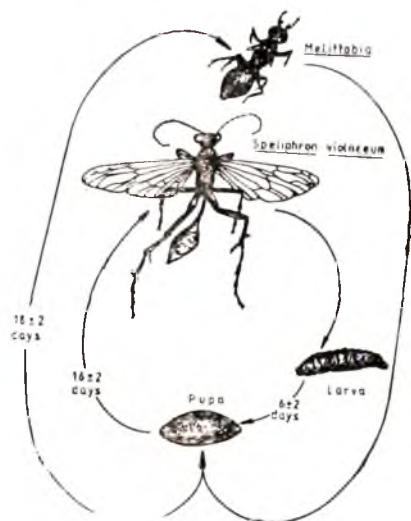


Fig. 1. Life cycle of the wasp *Speliphron violaceum* and its parasitoid *Melittobia*.

Occasionally, the chalcid wasp *Melittobia* pierces through the rim of the sealed hole and oviposits on the larva of *S. violaceum*. *Melittobia* times its oviposition in such a way that the batching of the eggs is synchronised with commencement of the pupation of the host. Samples of *S. violaceum* pupae from which adults did not emerge within 16 days of pupal period, were transferred to glass vials and maintained in total darkness. In about 2 days after their transfer, *Melittobia* adults emerged from the host pupa. Therefore, *Melittobia* completes its development within the host in about 18 ± 2 days (Fig. 1). Briefly, spider—*S. violaceum*—*Melittobia* constitute an idea prey—predator—parasitoid system.

Population census of the larva of *S. violaceum* and its parasitoid *Melittobia* covering 665 holes of unused electrical sockets in three adjacent buildings at Madurai Kamaraj University was undertaken between 1977 and 1979. The sockets chosen for the survey were marked and inspected twice a day. Holes used for larviposition by *S. violaceum* and the date of larviposition and emergence were noted. After emergence, the debris in the holes were removed. As a single larva is deposited in a hole, the number of holes occupied by *S. violaceum* represents the larval population. The number of holes from which *S. violaceum* does not emerge within 22 days after larviposition represents the number of *S. violaceum* infected by *Melittobia*. The difference between the number of *S. violaceum* larviposited and that infected by *Melittobia* represents the number of *S. violaceum* adults emerged. About 25 infected pupae were transferred to separate vials and the number of *Melittobia* emerging from each was counted. On an average 151 ± 19 *Melittobia* emerged from a single *S. violaceum* pupa. Multiplying the number of infected pupa by 151, number of *Melittobia* emerged during different months was calculated. From randomly chosen sockets from adjacent buildings, a minimum of 25 holes were opened every month immediately after larviposition and the number, size the mean weight of a spider packed in each hole was estimated. The number of prey exploited by *S. violaceum* during different months was calculated by multiplying the number of holes occupied with the mean number of spider/hole. Using the mean weight of a spider during different months, prey exploited in terms of biomass was calculated.

RESULTS AND DISCUSSION

Data on monthly changes in the population of *S. violaceum* and *Melittobia* are presented in Table 1. During November 1977, as many as 176 of the 665 holes chosen for the survey were occupied by *S. violaceum* larvae. The lowest number of larvae was recorded during April

1978. Size of *S. violaceum* population and hence that of the parasitoid *Melittobia* depended on rainfall (Fig. 2). Such fluctuations in population size are not uncommon among wasps (see PRAKASH & PANDIAN, 1978). During 1977—1978, as 1, 110 larvae were deposited compared to 1,032 during 1978—1979. Despite the

TABLE 1. Population dynamics (number) of the predatory wasp *Speliphron violaceum* and its parasitoid *Melittobia* sp. Incidence of infection and search power of the parasitoid are also given.

Year Month	<i>S. violaceum</i>		<i>Melittobia</i>	Incidence of	Search
	Larva	adult	adult	infection (%)	power
<i>1977</i>					
September	169	113	8456	33.1	—
October	174	139	5285	20.1	3.45×10^{-6}
November	176	134	6342	24.0	2.60×10^{-6}
December	140	105	5285	25.0	3.61×10^{-5}
<i>1978</i>					
January	113	65	7248	42.5	4.05×10^{-6}
February	66	36	4530	45.5	7.42×10^{-5}
March	61	40	3171	34.4	1.74×10^{-5}
April	22	21	152	4.6	3.22×10^{-4}
May	38	35	453	8.9	3.62×10^{-3}
June	27	26	151	4.7	7.54×10^{-4}
July	43	39	604	9.3	3.08×10^{-3}
August	81	70	1661	13.6	1.05×10^{-3}
September	96	81	2265	15.6	1.02×10^{-4}
October	150	130	3032	13.4	1.97×10^{-4}
November	145	116	4379	20.0	1.12×10^{-5}
December	117	99	2718	15.4	4.90×10^{-5}
<i>1979</i>					
January	99	73	3926	26.5	6.52×10^{-5}
February	72	54	2718	25.0	7.85×10^{-6}
March	75	53	3322	29.3	1.50×10^{-5}
April	56	44	1812	21.3	8.79×10^{-5}
May	94	76	2718	19.2	2.86×10^{-4}
June	42	26	755	11.9	2.55×10^{-4}
July	33	30	453	9.1	3.19×10^{-4}
August	54	49	755	9.3	1.09×10^{-3}

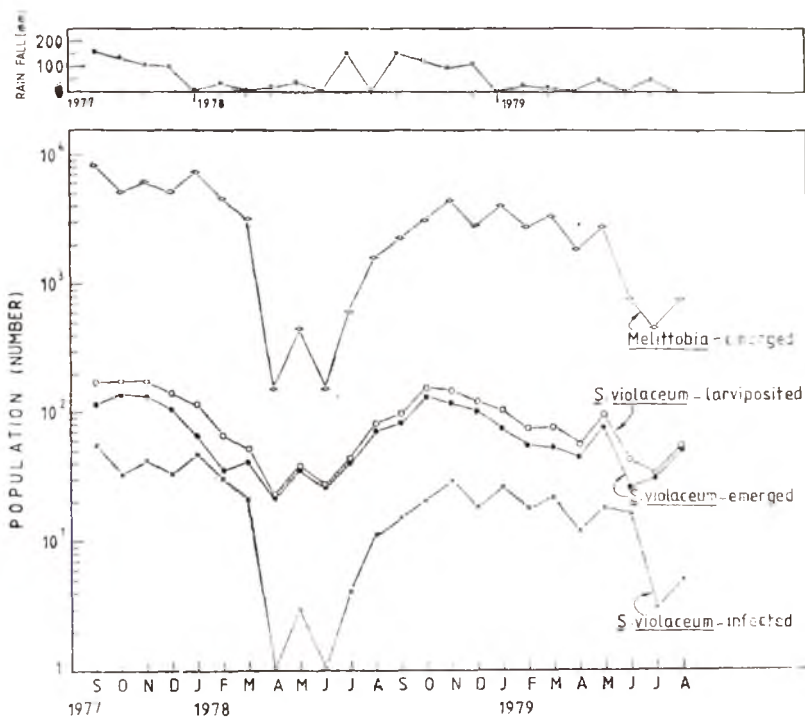


Fig. 2. Monthly changes in the population of *S. violaceum* larviposited, infected and emerged as well as adult *Melittobia*. Rainfall during the study period has been indicated in the upper pannel.

marginal difference in the number of larvae deposited during these years, the number of adults emerged was more or less the same (823 and 830 respectively). The remaining larvae succumbed to parasitisation by *Melittobia*. Size of *S. violaceum* population depended on the availability of spiders in the field. Investigating the effects of climate on growth and pattern of egg production in spiders, PALANICHAMY & PANDIAN (1983) found the argiopid spider *C. cicatrosa* oviposits large egg sacs (39 eggs/sac) more frequently (once in 6.5 days) during monsoon than during summer (18 eggs/sac at a frequency of once in 16 days). Therefore, thinning of spider population in the field appar-

ently due to scarcity of prey accounts for the decrease in the wasp population during summer.

Spiders not exceeding 8 mm length are packed inside the holes whose dimensions are 27 ± 5 mm depth, and 8.3 ± 1.0 mm diameter. Number of spiders provided for a *S. violaceum* larva varied during different months and was found to be dependent on the size of the spiders. For instance, in May 1978, when the spiders available were as small as 4.2 mg, 48 spiders were provided per larva as against 13 spiders with a mean weight of 15.4 mg in January 1979 (Table 2). However, in terms of biomass, the quantity

TABLE 2. Exploitation of prey (spider) by the predatory wasp *Speliphron violaceum*. Values on number of spiders provided/larva represent the mean (\pm SD) of the number of spiders provided for at least 25 larvae.

Year month	Spider/larva (Number)	Weight of a spider (mg)	Prey exploited	
			Number	Biomass (g)
1977				
September	29 ± 2	6.9 ± 1.3	4901	33.8
October	26 ± 3	7.5 ± 1.8	4524	34.8
November	16 ± 4	12.5 ± 2.2	2816	35.2
December	14 ± 3	14.3 ± 3.1	1960	28.0
1978				
January	18 ± 2	11.1 ± 1.9	2034	22.6
February	28 ± 6	7.1 ± 0.9	1848	13.1
March	38 ± 5	5.3 ± 1.2	2318	12.3
April	42 ± 4	4.9 ± 0.8	924	4.5
May	48 ± 3	4.2 ± 0.5	1824	7.7
June	33 ± 4	6.1 ± 0.8	891	5.4
July	37 ± 3	5.4 ± 0.5	1591	8.6
August	29 ± 4	6.9 ± 0.9	2349	16.2
September	27 ± 5	7.4 ± 1.0	2592	19.2
October	33 ± 6	6.1 ± 0.8	4950	28.0
November	14 ± 3	14.3 ± 2.3	2030	29.0
December	17 ± 3	11.8 ± 2.0	1989	23.5
1979				
January	13 ± 2	15.4 ± 2.6	1274	19.6
February	15 ± 3	13.3 ± 2.1	1080	14.4
March	18 ± 4	11.1 ± 1.8	1350	15.0
April	22 ± 4	9.1 ± 1.6	1232	11.2
May	32 ± 7	6.3 ± 0.9	3008	18.9
June	26 ± 5	7.7 ± 1.1	1092	8.4
July	34 ± 6	5.9 ± 0.8	1122	6.6
August	37 ± 4	5.4 ± 0.8	1998	10.8

of spiders provided during different months was around 200 mg/larva. Despite the hazards of spider availability and human disturbance in the laboratory, it is interesting to note that *S. violaceum* provided almost equal quantity of prey to its larvae during different months. Consequently, *S. violaceum* adults emerging

from electrical sockets in the laboratory varied very little in size and weighed 42 ± 3 mg. On an average a female carried 475 ± 30 oocytes in the ovary. However, females, visiting the laboratory for larviposition weighed from 15 to 60 mg and their fecundity (oocytes/female) had a highly significant correlation with weight

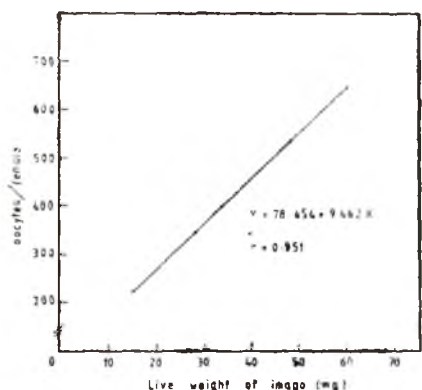


Fig. 3. Fecundity of *S. violaceum* in relation to the size of the female.

(Fig. 3). *S. violaceum* females emerging from laboratory populations do not reproduce in captivity and hence it was not possible to find out the number of young ones that a female can larviposit. It is likely that the female is not able to realise the full complement of oocytes. Under conditions of paucity of suitable holes for larviposition and scarcity of prey in the biocenosis, oocytes are resorbed by the female and utilised for self-maintenances. Over 45% of *Aedes aegypti* females receiving 1 μ l of blood have been found to resorb the oocytes and utilise the end products (LEA *et al.*, 1978). Hymenopterous females which are unable to locate proper oviposition sites or those prevented from oviposition also resorb their oocytes (PRICE, 1973; see also CHAPMAN, 1971).

Incidence of infection of *S. violaceum* by *Melittobia* was highest (45.5%) during February 1978 and lowest (3.7%) in June 1978. Corresponding values for 1979 were 29.3% in March and 9.1% in July (Table 1). It was uniformly low in 1978–1979. In the first year as many as 43,350 *Melittobia* were produced as against 23,500 during the second year. Obviously, the

peak population growth attained by *S. violaceum* between September 1977 and January 1978 was brought under control by the highest percentage of infection recorded in February 1978. Following NICHOLSON & BAILEY (1935), search power of the parasitoid was calculated. It ranged from 2.60×10^{-6} in November 1977 to 3.62×10^{-8} in May 1978 (Table 1). Compared to the search power of other hymenopterous parasites (e.g. 4.5×10^{-2} for *Normoniella vitripennis* parasitic on pupa of *Musca domestica*; DE BACH & SMITH, 1941) that of *Melittobia* was significantly low and it is likely to be responsible for the low incidence of infection which averaged 22.8% for the entire period of study.

From a host pupa weighing 100 mg, 151 ± 18 *Melittobia* adults emerged. *S. violaceum* larvae transferred to glass vials and fed on unlimited supply of paralysed spiders obtained from holes used for larviposition produced larger pupae; from a pupa weighing 138 mg, over 225 *Melittobia* adults emerged. Fecundity of *Melittobia* seems to be higher than that of several other hymenopterous parasites (30 eggs/female in *Pleolophus indistinctus*; PRICE, 1973). However, *Euceros frigidus* which deposits its eggs on the foliage of host plant produces as many as 1,000 eggs/female (TRIPP, 1961). Such high fecundity is obviously related to the low probability of host finding as well as survival in the host (PRICE, 1975). Pupal parasitoids have a higher probability of survival than those infecting very early stages of the host. Although *Melittobia* is a pupal/late larval parasitoid, its moderately high fecundity is understandably due to the difficulty involved in locating the concealed hosts (see MUTHUKRISHNAN & PANDIAN, 1983).

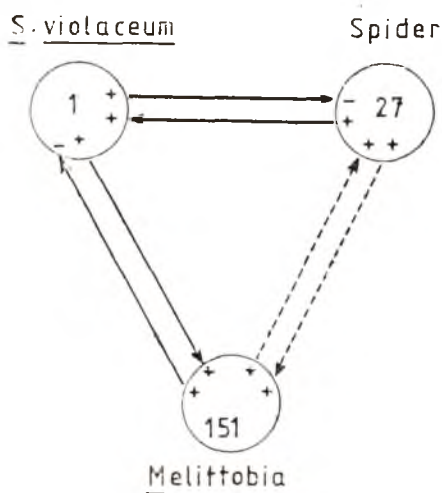


Fig. 4. A diagrammatic model showing the regulation of spider—*S. violaceum*—*Melittobia* populations. Continuous lines indicate the direct impact of one over the other as indicated by the arrow; discontinuous lines show the indirect impact of *Melittobia* over the spider population. + or - signs represent addition or removal of the number of individuals shown in the circle.

Briefly, density of *S. violaceum* depends on the biomass of prey captured, while that of *Melittobia* is determined by the availability of hosts. Population density of the prey (spider), predator (*S. violaceum*) and the parasitoid (*Melittobia*) are interdependent. For the successful emergence of a predator about 27 ± 10 spiders are predated by a female *S. violaceum*. Infection of a single predator by a *Melittobia* leads to an increase in the size of the prey population by 27 and that of the parasitoid by 151 (Fig. 4). From the available data on the number of spiders exploited (X_1), number of *S. violaceum* larviposited (X_2) and that infected by *Melittobia* (X_3), it is possible to predict the size of the adult *S. violaceum* population (Y). The following multiple regression equation explains the relation between these variables:

$$Y = (-2.42 \times 10^{-8}) + (5.32 \times 10^{-11} X_1) + (1X_2) + (1X_3)$$

The multiple correlation coefficient (0.999) for the above relation is statistically highly significant.

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EVALUATION OF BIOASSAY TECHNIQUES FOR MEASUREMENT OF LINDANE RESISTANCE IN *TRIBOLIUM CASTANEUM* (HERBST)

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Bioassay methods involving filter paper impregnation, residual films and direct spraying under a Potter's tower, were evaluated in the laboratory for their suitability as standard methods for carrying out inheritance studies in lindane-resistant and susceptible strains of *Tribolium castaneum*. Direct spray method was found suitable as the resistance ratio obtained was high and there was no overlapping between the Ld-p lines of the parental strain.

(Key words: lindane-resistance, bioassay techniques, *Tribolium castaneum*).

INTRODUCTION

The level of resistance in an insecticide resistant strain depends greatly on the bioassay method employed for assessment (BHATIA & PRADHAN, 1968, 1970). The choice of the method for proper estimation of the resistance is essential especially in investigation on the inheritance of insecticide resistance. The present investigations were undertaken to assess the suitability of different bioassay methods for studying lindane inheritance in *Tribolium castaneum*.

MATERIAL AND METHODS

The lindane-resistant strain (LR) was originally selected by BHATIA & PRADHAN (1970) by rearing the insects in a lindane-treated medium for 10 generations; it was further selected by rearing in a medium treated with 600 mg lindane kg⁻¹ for 53 generations, and for one further generation in a medium treated with 800 kg⁻¹. The emerging

adults were then raised as single pair culture in 100 mg lindane kg⁻¹, and reared for four more generations in similarly treated medium for use in the present studies. The susceptible strain(S) used in the studies was also maintained as a single pair culture started in the 65th generation and was reared throughout without any insecticidal pressure. The general rearing of the test insect in wheatflour was carried out as per method given by BHATIA & PRADHAN (1968). Studies were carried out at 30 ± 1°C and 70 ± 5% R.H.

Three bioassay methods compared were: i) filter paper impregnation, ii) residual films and iii) direct sprays. The filter paper impregnation method was the one described by CHAMP & CAMPBELL-BROWN (1950) and recommended by FAO (1970) for detection and measurement of insecticide resistance in the red flour beetle. This method was performed in two ways: (a) by preparing insecticide concentrations in a mixture consisting of petroleum ether (60–80°C B.P.), acetone (AR) and risella-17 oil (3:1:1), (b) by adding two parts of dibutyl phthalate (DBP) to the above mixture. Whatman's No. 1 filter papers (9 cm diameter) were impregnated by the desired concentration by supporting the filter papers on three fine pin points at the time of application. The aliquots (0.85 ml) of insecticide solutions were spread on each filter paper

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TABLE 1. Toxicity data of lindane to the adults of lindane-resistant (LR) and susceptible(S) strain *T. castaneum* using different testing methods.

Testing method	Strain	Heterogeneity D. F.	X ²	LC ₅₀ (g litre ⁻¹)	Fiducial limit (g litre ⁻¹)	Regression equation Y =	Resistance ratio
1. Filter paper impregnation							
a) Pet. ether + Acetone + Risella-17 oil (3:1:1)	S	3	2.9669	3.42	2.56-4.58	2.1484 X + 1.7042	-
	LR	-	-	>10.00*	-	-	-
b) Pet. ether + Acetone + Risella-17 oil + DBP (3:1:1:2)	S	S	0.1435	8.13	5.77-11.44	1.7311 X + 1.6937	10.6
	LR	-	-	86.38	73.43-101.60	3.5177 X - 1.8188	10.6
2. Residual films							
	S	4	3.6058	2.54	2.08-3.09	2.7595 X + 1.1255	-
	LR	-	-	>70.00**	-	-	-
3. Direct sprays							
	S	3	3.0475	0.89	0.76-1.04	3.0531 X - 0.9467	45.1
	LR	3	0.2876	40.01	34.23-46.77	3.1016 X + 0.0305	45.1

*LC₅₀ value could be estimated because of evaporation of acetone and crystallization of lindane in the concentrations above 10 g litre⁻¹. Lindane-resistant strain did not give any kill upto 10 g litre⁻¹.

**ZC₅₀ value of lindane could not be estimated as the highest emulsion concentration of lindane (70 g litre⁻¹) gave only 48.28% mortality.

with the help of 1 ml pipette. These were allowed to dry for one to two minutes and then transferred to petri dishes, and were allowed to stand overnight. A test comprised three replications of four to eight concentrations. Adult beetles, 10–15 days old, starved for 24 hours, were released on the test filter papers in batches of 25 to 40 insects per replication to which they were confined by glass rings (7.0 cm diameter and 3.5 cm in height). The insects were exposed to filter papers for 24 hours after which mortality was recorded.

In residual film method, the films were prepared on a petridish (10 cm diameter) by spraying one ml insecticidal emulsion under the Potter's tower at a pressure of 5 lbs inch⁻² (3.5 Kpa). In formulation of the emulsions, benzene (100 ml litre⁻¹) and Triton X-100 (6 ml litre⁻¹) were kept constant (benzene level was raised to 200 ml litre⁻¹ in case of concentrations more than 30 g litre⁻¹). The control dishes were sprayed with benzenoted emulsified water. Dishes were allowed to dry for about one hour at room temperature. Each treatment was replicated thrice and 25–40 adults, 10–15 days old, were released in each dish. Before treatment insects were starved for 24 hours at $30 \pm 1^\circ\text{C}$ and $70 \pm 5\%$ R. H. In the third method i. e., direct spray, the procedure was similar to that used for residual films except that the insects were first released in the petridishes and sprayed under the potter's tower.

The data obtained were subjected to probit analysis (FINNEY, 1952).

RESULTS AND DISCUSSION

The toxicity data of lindane to the adults of the S and LR strains by different bioassay techniques are given in Table 1. The results show that the resistance level of the LR strain was 10.6 times with impregnated filter paper method when DBP was added (b) and 45.1 times with the direct spray method. With the impregnated filter paper method when DBP was not added (a) and with the residual film, the exact LC₅₀ value of the LR strain could not be estimated due to

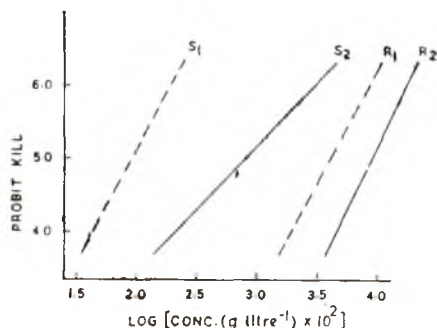


Fig. 1. Lc-p lindane applied as direct sprays (shown by broken lines S_1 and R_1) and impregnated filter papers (indicated by bold lines S_2 and R_2) to the adults of susceptible (S) and lindane-resistant (LR) parents of *T. castaneum*. Bold lines S_2 and R_2 reveal the overlapping tendency.

limitations either in the administration or in the formulation of required higher concentrations of the insecticide. Thus with these methods, exact resistance ratios could not be obtained. Although the ratios could be worked out by extrapolation, these would not be suitable for interpretation of the results on inheritance of lindane resistance. Hence the use of these methods in inheritance studies was ruled out. As for the methods by which definite resistance ratios could be obtained, the ratio estimated by the impregnated filter paper method with addition of DBP (b) was 10.6 as compared to 45.1 with the direct spray method. Comparison of these ratios showed that the one estimated by the impregnated filter paper method was low and there was overlapping between the log concentration-probit mortality regression (Lc-p) lines S_2 and R_2 of S and LR strains, respectively (Fig. 1). Therefore, this method was also not suitable for the inheritance studies, since with the estimated small difference in the degree of resistance between S and LR parental strains and

the overlapping of their regression lines, proper interpretation of the results from different generations of crossing would not be possible. However, these requirements were fulfilled by the direct spray method i. e., the resistance ratio was high and there was no overlapping between the regression lines S_1 and R_1 of the parental susceptible and resistant strains, respectively (Fig. 1). Hence this method was found suitable for carrying out the inheritance studies in strains of *T. castaneum* where higher difference in the degree of resistance between S and L R strains and no overlapping between their regression lines were obtained (KUMAR & BHATIA, 1982). These studies show the importance of choosing proper bioassay method for the type of studies envisaged.

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DROSOPHILA NEOTRAPEZIFRONS - A NEW SPECIES FROM PORT BLAIR, ANDAMAN ISLANDS

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The new species *Drosophila neotrapezifrons* collected from Port Blair, Andamans has been taxonomically described. The interrelationships with other similar species are discussed.

(Key words: *Drosophila*, Port Blair, *D. neotrapezifrons*)

INTRODUCTION

Many workers have contributed to our knowledge on the *Drosophila* fauna of the mainland India (Gupta, 1974; Reddy, 1994; Gowda, 1979; Prakash, 1979). But thus far only one attempt has been made to screen *Drosophila* species of the neighbouring Andaman and Nicobar Islands (Gupta and Raychaudhuri, 1970). As islands are considered to be fertile regions for population differentiation and speciation, a project was undertaken to explore *Drosophila* fauna present in Andaman and Nicobar Islands. These are tropical island groups of Bay of Bengal forming an accurate chain of 1120 km. These islands with their humid climate, harbour evergreen forests with sparsely cultivated fields and plantations. The present paper deals with the description of a species collected from Port Blair (Andamans).

Drosophila neotrapezifrons sp. nov.

Male and female:- Brownish yellow flies, females larger than males. Mean length, males 1.71 mm (range 1.63—1.83 mm) females 2.00 mm (range 1.93—2.07 mm).

Head, male and female:- Arista with 7 branches (4/3) including the fork; An-

tenna yellowish brown; cheek light yellow with vibrissae having three large bristles with a group of small bristles. Palpi yellowish with a stiff bristle. Carina narrow. Eyes orange red. Anterior orbital small proclinate, middle and posterior orbitals reclinate, orbital bristles in the ratio of 1:2:1. Inner verticals small reclinate, outer verticals large reclinate. Outer verticals $1\frac{1}{2}$ times larger than inner ones ocellar triangle small shiny with two long bristles.

Thorax, males & females:- Brownish yellow. Aerostichal hairs in 8 regular rows. Anterior dorsocentrals $\frac{3}{4}$ the posterior. Anterior scutellars convergent. Posterior scutellars convergent and crossed. Sternopleurals with three large bristles and 5 to 8 smaller ones. Anterior sternopleural $\frac{3}{4}$ the posterior; and the middle one is the smallest. Both anterior and posterior alars are of same length.

Wings, males and females:- Transparent, mean length of the wings in males 1.16 mm (range 1.10—1.23 mm) and that of females 1.27 mm (range 1.23—1.33 mm). The wing indices are given in Table 1. These are calculated following the formulae of Okada (1956).

TABLE 1. Wing indices of *D. neotrapezifrons*.

	Costal index	4V index	4C index	5X index
Male	1.76 1.68–1.87	2.70 2.50–3.15	1.66 1.50–1.92	2.69 2.33–3.00
Female	1.61 1.70–1.74	2.66 2.33–2.84	1.72 1.53–1.85	2.65 2.40–3.25

Legs:- Preapicals on all tibiae and apicals on first and second. First tarsal segment of the foreleg in male carry two sets of sex combs, proximal set with 22 longitudinal teeth and the distal set with 16 teeth. Few anterior teeth of the proximal set are united (Fig. 1).

Fig. 1. *D. neotrapezifrons*: Sex comb.

Abdomen:- Males and females: Brownish yellow. Only the borders of the tergites are pigmented.

Periphallic organs:- (Fig. 2). Epan-drium (Genital arch) brownish yellow, broad dorsally and laterally. Epan-drium carries about 20-25 bristles. Both primary and secondary surstylus (claspers) present. Primary surstylus with a set of short teeth arranged in a row and a set of 8 irregularly arranged teeth. Secondary surstylus continuous with cerci (anal plate), and carries 3 large curved black medium teeth and 3 small teeth arranged in a row along the anterior margin. Cerci brownish with 11–13 bristless.

Phallic organs:- Aedeagus brownish yellow, long, broader basally, not hirsute and apically rounded. Anterior gonapophyses (parameras) are small with a few apical sensilla. Posterior gonapophyses are large with a chitinous spine which is directed posteriorly. Ejaculatory apodeme long, ventral fragma broad dorsally and laterally.

Egg guide:- (Fig. 4) Brown with about 12 to 14 teeth.

Internal characters:- Testes yellow with 5 coils. Paragonia relatively smaller than testes. Ejaculatory duct tubular without any enlargement (Fig. 6). In females the spermatheca is small, ventral receptacle is tightly coiled. Paragonia small (Fig. 5). Malpighian tubules 2 pairs and free.

Egg filaments: Two slender filaments. Slightly flattened apically.

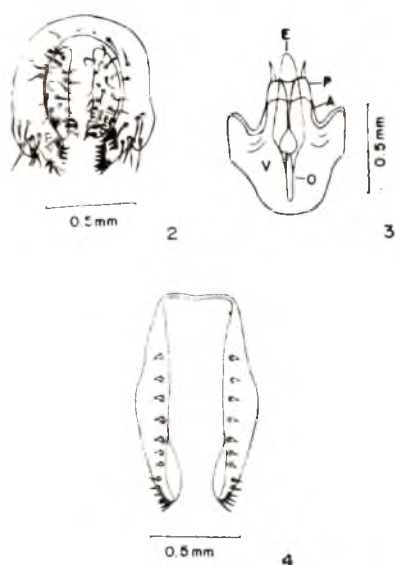


Fig. 2—4. *D. neotrapizifrons*. 2. Peripheral phallic organ: C. Cerci E. Epandrium P. Primary surstylus, S. Secondary surstylus. 3. Phallic organ: A. Anterior gonapophyses, E. Aedeagus P. Posterior gonapophyses O. Apodeme V. Ventral fragma. 4. Egg guide.

Pupae: Brownish yellow, Anterior spiracle with 8—22 branches. The species can be cultured only for two to four generations on wheat cream agar medium.

Holotype: *Male:* India. Andamans, Port Blair 14 × 1979 Coll Ranganath. H. A. & Krishnamurthy. N. B. Deposited in the museum [of Department of Zoology, Manasagangotri, University of Mysore, Mysore, India 570 006. **Allotype :** ♀, same as above. **Paratypes:** ♂♂ and 5♀♀ India. Andamans, Port Blair Coll Ranganath. H. A. & N. B. Krishnamurthy, Deposited in the Department of Biology, Tokyo Metropolitan University, Setagaya-Ku, Tokyo, Japan and some will be deposited in Zoological Survey of India, Calcutta.

Distribution:- India. Andamans, Port Blair,

Relationships and Remarks:- The species under description possesses coiled ventral receptacle, eggs with two blunt

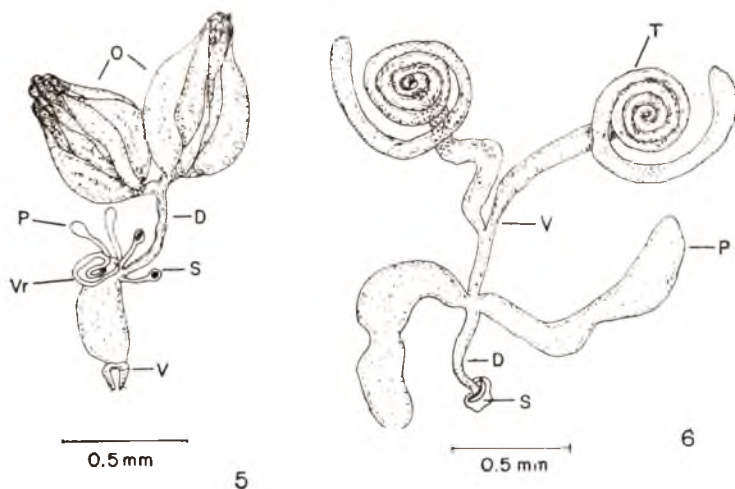


Fig. 5—6. 5. Female reproductive system: D. Oviduct; O. Ovary; P. Paragonia; S. Spermathecae; V. Egg guide; Vr. Ventral receptacle; 6. Male reproductive system: D. Anterior ejaculatory duct; P. Accessory gland; S. ejaculatory bulb; T. Testis; V. Vas deferens.

filaments and the nature of its abdominal banding pattern and these features justify its inclusion under the subgenus *Sophophora*. Further, because of the following features, namely presence of sex-comb, periphalllic organs with well developed epandrium, surstylus with teeth, phallic organs with anterior and posterior gonapophyses and coiled testes warrant its inclusion in the *melanogaster* species group. The contiguous nature of the cerci and secondary clasper, presence of black medium teeth on the latter and the bare tip of the aedeagus are characteristics of the *montium* species subgroup (cf. Bock and Wheeler, 1972). So the species under description comes under *montium* subgroup of the *melanogaster* species group of the subgenus *Sophophora*.

Prof. Okada (Personal communication) has remarked that this new species is close to *D. trapezifrons*, Okada (1966) but distinct from it. The species under description resembles *D. trapezifrons* in the shape of head; sex comb in two sets with same number of teeth, presence of preapicals on all tibiae, the distribution of bristles on genital arch and cerci. However it differs from *D. trapezifrons* in having 8 rows of acrosticals, irregularly arranged teeth on the primary surstylus, with three large teeth and in the organization of phallic organ. Hence this

species is christened as *Drosophila neotrapezifrons*.

Acknowledgements: We are grateful to Prof. T. OKADA, Japan for helping in identification; to UGC for research grants; to ZSI, Port Blair for assistance in collection trips and to Dr. S. R. RAMESH for drawings.

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A STUDY ON THE GENUS *ARATHRIPS* BHATTI (THYSANOPTERA : THIRIPIDAE) FROM DEHRADUN (INDIA)

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The genus *Arathrips* and the species *A. cus* Bhatti are redescribed and additional characters are given. The relations of this genus with *Tusothrips* Bhatti are discussed. The male of *A. cus* is described for the first time.

(Key words: redescription, *Arathrips cus* Bhatti, *Tusothrips* Bhatti, first record, Thysanoptera, Thripidae)

INTRODUCTION

The interesting genus *Arathrips* Bhatti was described from a single female (Bhatti, 1967), whose habitat was unknown. We have come across a flourishing population in Dehradun, in the terminal tender leaves of *Ficus bengalensis*. We have found specimens of both sexes so that the taxonomy of the genus and its type-species can be understood better, based on the series of specimens. Data on the type-specimen were provided by the author of the species and this can be supplemented with our own observations on the material from Dehradun. This opportunity is being taken to redescribe the genus and the species in detail along with suitable illustrations. All measurements are in μ m.

Genus *Arathrips* Bhatti

Arathrips Bhatti, 1967, *Thysanoptera nova indica*, p. 16. Type species *Arathrips cus* Bhatti, 1967, p. 16, by original designation.

The full description of the genus is given below, following the earlier brief characterisation (Bhatti, 1967).

Antennae 8-segmented, with forked sensae cones on segments III and IV, microtrichia present on segments III to VI, segment I without a pair of dorsal apical setae (a total of 6 setae in addition to the 2 dorsal and 3 ventral microsetae); II with dorsal setae based of companiform sensilla. Head broader than long; with one pair of small interocellar setae and a pair of antecellar setae which are much longer than interocellars. Maxillary palpi 3-segmented, slender, with middle segment very short. Pronotum with 2 long setae at each posterior angle. Frons entire, undivided. Mesothoracic sternopleural sutures present. Spinula absent on meso and metasternum. Median pair of mesonotal setae far ahead of posterior margin; metascutum showing reticulate pattern. Mesoepimeron with a few longitudinal anastomosing lines and covered with a dense pubescence of microtrichia. Tarsi 2-segmented. Fore wings with a few setae (4) on lower vein; posterior fringes strongly undulated. Abdominal terga II to VIII and sterna II to VI (♀) or II to VII (♂) with continuous postmarginal flanges; laterotergites apparently not marked out; pleurites marked

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TABLE 1. Comparison of *Arathrips* and *Tusothrips*.

<i>Arathrips</i>	<i>Tusothrips</i>
(1) Anteoellar setae better developed and longer than interocellar and postocular setae.	Anteoellar setae about similarly developed and as long as interocellar and postocular setae.
(2) Metascutum without complete reticules and median pair of setae at anterior margin.	Metascutum with complete reticules and median pair of setae far back of anterior margin.
(3) Meso and metaspinaula absent.	Mesospinaula present or absent metaspinaula absent.
(4) Male abdominal sterna III to VII each with a large transverse gland area situated posterior to antecostal line.	Male abdominal sterna III to VII each with rudimentary gland area situated just in front of and joined with the antecostal line.

out by sutures, but appear to incorporate part of laterotergite area because seta S6 is located on these. Sternum II with two pairs of primary setae. III to VII each with 3 pairs of primary setae; all these setae inserted at posterior margin, except the median pair (S1) on female sternum VII is far ahead of posterior margin, accessory setae absent. Tergum X split longitudinally in female, not split in male. Male with abdominal tergum IX medially bearing a single, stout, upraised horn-like process carrying two small fusiform processes. Sterna III to VII of male each with a well developed gland area, broader than long, near the antecostal line.

The genus *Arathrips* Bhatti shows close affinity with *Tusothrips* Bhatti because of the presence of postmarginal flange on abdominal terga and sterna, and only a few (4) setae on the lower vein of fore wing. Both genera possess a strong median elevated projection on abdominal tergum IX of male. But they are separable by the characters given in the Table.

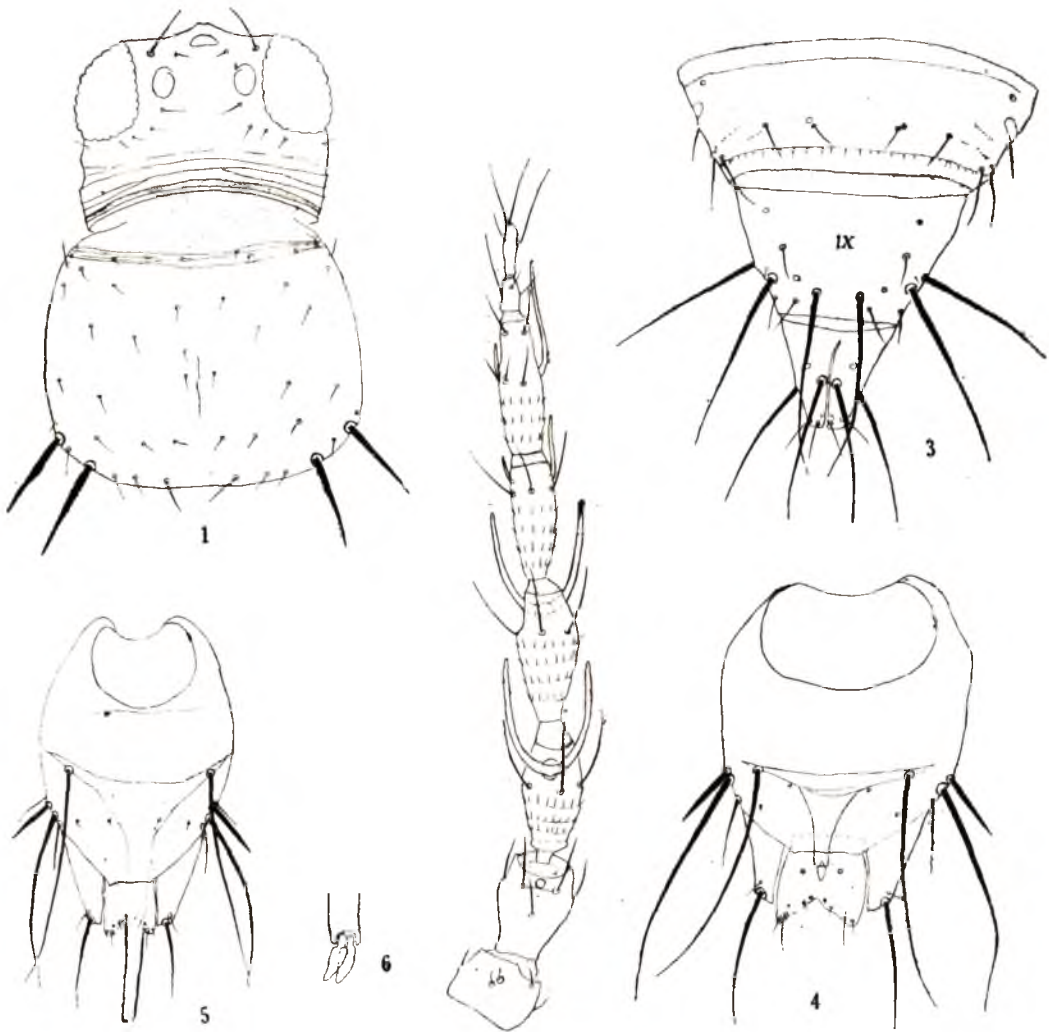
Arathrips cus Bhatti (Figs 1—6).

Arathrips cus Bhatti, 1957, *Thysanoptera nova indica*, p. 16. ♀, Holotype ♀,

India: Jabalpur, Madhya Pradesh (JSB, New Delhi).

Female (macropterous): Body dark brown, antennal segments I and II concolorous with body; III-V yellowish, slightly shaded at apex, VI-VIII brown, VII-VIII and basal two-thirds of VI lighter. Mouth cone and prosternum yellow. Fore and mid femora yellowish, but with brown on convex side, more so on middle femur; hind femur dark brown except the paler basal third. All tibia and tarsi yellow, unguitractor plates brown. Fore wings pale yellowish but weakly shaded with grey in the distal two-thirds, but darker in middle, anal lobe greyish. Hind wing with a median longitudinal dark brown streak. Cells orange. All setae subhyaline, yellowish, but those on abdomen, especially on posterior segments, shaded brown.

Head L112-128, W at eyes and cheeks 159-168. Interocellar setae 15-18 long, anteoellar setae 34-38 long, postocular setae 8 pairs, No. I 18-22 long, II to VI subequal, 11-16 long, VII 17-18, VIII 10-12 long; Maxillary palpi 3-segmented, L (and W) of segments: I 25-31 (6), II 8-10



Figs. 1—6 *Arathrips cus* Bhatti, 1—Head and prothorax, dorsal, ♀ (Sculpture omitted); 2—Antenna (left), dorsal, ♀; 3—Terminal abdominal segments (VIII-X), dorsal, ♀; 4 to 5—Terminal abdominal segments, ♂; 6—Tip of median process (lateral view), ♂.

(4), III 19 (3). Head smooth except a few transverse lines posteriorly on the dorsum, the posterior-most lines most prominent. Median ocellus 21-22 in width, 22-23 apart from paired ocelli, paired ocelli W 16, L 17 and 35-36 apart from each other. Antennal segment II without microtrichia, III and IV with forked long sense cones, on III 41-47, on IV 39-47.

on VI 36 long. Total length of antennae 270-303; L (and W) of segments: I 25 (29), II 33-34 (25-26), III 49-50 (19), IV 47-53 (19), V 37-41 (16-17), VI 43-48 (15-16), VII 9-10 (7), VIII 16-18 (4).

Pronotum L 134-164, W at anterior margin 165-168, W at posterior margin 208-211; surface smooth except for a couple of dark transverse lines anteriorly and

a small median longitudinal streak. Posteroangular setae, outer 49-59, inner 64-68 long. Posteromarginal setae 4 pairs, including those at angles, innermost posterior marginal setae longest, 34-36 long. Median pair of mesonotal setae far ahead of posterior margin, 19-21 long. Mesoscutum with transverse lines. Metascutum with a pair of companiform sensillae, median pair of setae marginal, inner 46-48, outer 35-39 long; sculpture of reticulate pattern, though not forming complete reticules.

Fore wings L645-742, W at middle 51-54; costa with $1+22$ to 27 setae, the first costal seta (L41) of the series longer than the seta immediately succeeding it, costal fringes commencing after 7th costal seta; upper vein with $1+3+3$ basal setae not reaching up to the middle of wing and $1+1+1$ setae in distal half; lower vein with 4 setae ($3+1$ or $2+1+1$); scale with 5 setae and one discal seta.

Abdomen mostly without sculpture, except very few weak, widely spaced transverse lines on the sides of abdominal terga II to VIII and few lines on tergum I; closely placed weakly developed transverse anastomosing lines on tergum IX anterior to the bases of posteromarginal setae. Tergum II with 3 lateral marginal setae. Terga II to VIII with continuous extension beyond posterior margin but less prominent on terga II to IV very clearly frill-like on tergum VIII, sterna II to VII with posterior extensions but on VII the extension absent between the primary setae S 2. Sternum II with 2 pairs of primary setae; III to VII each with 3 pairs; all these inserted at posterior margin, except the median pair (S1) on sternum VII which is far ahead of posterior margin. Sterna without accessory setae. A few rows of microtrichia along lines of sculpture on the extreme lateral sides

and close to the posterior margin of terga V to VIII; weakly developed comb having a few microtrichia on tergum VIII present. Median pair of tergal setae widely apart and a pair of companiform sensillae in the middle of terga II to VII. Tergum IX with two pairs of companiform sensillae, one of these close to the medio-dorsal setae. Setae on IX: md 37-41 long, their bases 434-437 apart; S1, 126-148; S2 134-161; S3, 119-129; S4, 120-125 long; with 5 pairs of smaller setae; on X: S1 113-119; S3, 104-113 long, with 4 pairs of minor setae along the posterior margin. Tergum X split longitudinally through most of its length except at extreme base. Ovipositor 262-266 long. Total body length (distended): 1326-1698.

Male (macropterous): General body colour dark brown, except antennal segments III-V, fore legs, middle and hind tibiae, and tarsi yellow; middle and hind femurs shaded brown in distal two-thirds; basal portion of anal lobes and three fourths of fore wings shaded; ocelli crimson red. But teneral forms greyish brown or dark brown, with the antennal segment V greyish brown but yellowish in basal fourth; legs yellow, except hind femora which are shaded brown in middle; fore wings yellowish. Ocelli crimson red.

Head broader than long, L 103-120, W 140-167 across eyes, 142-156 across base. Medianocellus 16-19 in width; paired ocelli 16-17 in width, and 18-19 in length, paired ocelli 32-35 away from each other, and 16-17 away from median ocellus, antecellar setae 35-50 long, 56-66 apart from each other; interocellar setae 20-22 long and placed just above inner margin of paired ocelli and well within the ocellar triangular, postocular setae 8 pairs, No. 1 19-20, No. 2 10-15 long and placed just below No. 1 in some specimens. Total length of antennae 266-288; L (and W) of segments:

I 19-25 (28-31), II 28-32 (22-26), III 47-53 (18-20), IV 47-53 (18-20), V 36-44 (15-17), VI 44-47 (13-14), VII 9-10 (6-9); VIII 16-19 (4-6). Antennal segments III and IV with forked sense cones, on III 48-50 long and on IV 38-40 long. Mouth cone 102-126 long and reaching near the ferna: maxillary palpi 59-64 long and 3 segmented; L (and W) of segments: I 28-31 (6), II 12-13 (5), III 16-17 (4); labial palpi 16-19 long.

Pronotum broader than long, L 120-142, W at anterior margin 151-167, W at posterior margin 189-195. Posteroangular setae outer 58-69 long, inner 54-85 long; posteromarginal setae 4 pairs including those at the angles, the innermost 25-37 long and 35-41 apart from each other.

Fore wings L 616-742, W at first distal setae 50-57, costa with 24-26 setae and costal fringes start after 7th costal setae; upper vein with 4+3+1+1+1 setae; lower vein with 4 setae; scale with 5+1 setae. Hind wings 546-700 long. Metanotal setae inserted marginally, inner pair 47-57 long, outer pair 35-40 long.

Abdomen L 868-960, W at segment V 284-294, W at segment IX 145-150, W at segment X 91-110. Abdominal terga II-

VIII and sterna with continuous postmarginal extensions. Terga VI-VIII with a few rows of microtrichia along lines of sculpture on the extreme sides. Glandular areas present on sterna III to VII, W (and L) of glandular areas: on III 40-91 (14-22), IV 44-97 (14-22), V 47-94 (15-16), VI 41-97 (15-16), VII 34-75 (15-16). Abdominal tergum IX with a single, stout, median process (L 70-306) carrying a pair of club like structures. Total body length (distended): 1146-1428.

Specimens examined: INDIA: UTTAR PRADESH, Dehradun, 7♀♀, 8♂♂, 15.i.1980, tender leaves of *Ficus bengalensis*, leg. Vijay Veer, 1♀, 1♂ and 2♀♀ with the same data but collected on 20.iv.1980 3.vi.1977 respectively.

Acknowledgement:—We wish to express our gratitude to Dr. J. S. Bhatti, Hans Raj College, New Delhi for supplying the unpublished informations on the type species and for his reviewing the manuscript. Dr. S. K. Kulshrestha, D. A. V. College, Dehradun, is thanked for guidance and facilities. Thanks are also due to UGC, New Delhi for financial assistance to the senior author (V. V).

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RESISTANCE OF FEMALE *PERIPLANETA AMERICANA* L. TO DIELDRIN

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Dieldrin, a cyclodiene compound, when applied to both the sexes of american cockroaches at different loci, caused significantly reduced knockdown in females as compared to males showing the greater tolerance by females for dieldrin. The plausible explanation for such resistance of females to dieldrin has been discussed.

(Key words: resistance, female *Periplaneta americana*, dieldrin)

INTRODUCTION

Little information is available on the resistance mechanism in the two sexes of individual species. The latest available report is of SAXENA & SAXENA (1982) who have discussed the resistance shown by female cockroaches to malathion. In the present report the resistance of females to dieldrin and its probable reasons have been discussed.

MATERIALS AND METHODS

Newly emerged adults of both sexes of the American cockroach, reared in the laboratory (under conditions of $30\pm 2^\circ\text{C}$ and $65\pm 5\%$ relative humidity) were used for the experiments. Dieldrin, a cyclodiene compound dissolved in benzene to desired concentrations (0.5, 1 and 2%) was applied topically to fore-femur, wingbase, pronotum and 2nd abdominal sternite of the cockroaches weighing 1.770–1.774 gm each) of both the sexes. The period required for complete knockdown by the treated insects was recorded. The treatments were given to batches of 10 insects. At least 5 replicates of 10 cockroaches each were used at each concentration level. Controls were also kept. For histopathological studies, autopsy was done after 15, 30, 60, 180 and 300 minutes of treatment. The brain and midgut were

dissected out in physiological saline and fixed in Bouin's fixative. The sections were stained in haematoxyline and eosin.

RESULTS AND DISCUSSION

The main observation recorded on treating the roaches with different concentrations of dieldrin is the differential susceptibility shown by both the sexes. The results reveal that the female cockroaches are resistant as compared to susceptible males as shown by significantly quicker knockdown response (Table 1, 2 & 3). The pathological changes in the midgut and brain of treated males are found more intensive than those in females. The histological changes in the brain include vacuolization, pycnosis in neuronal cell nuclei (Figs. 1, 2) and separation of neural and perilemma (Figs. 3, 4) and in the gut include enhanced secretory activity as evidenced by oozing of secretory globules in the lumen (Figs. 5, 6), contraction of muscle fibres, detachment of nidi cells from the muscular lining, chromatolysis and vacuolization in glandular cell of cytoplasm of epithelium.

TABLE 1. Effect of dieldrin (.5%) on *Periplaneta americana*.

Amount of chemical applied	Place of application	% solution (in benzene)	No. of insects	Sex treated	Range of knockdown time (min)	Mean knock-down time
.01 ml	Hind thoracic sternite	.5% Dieldrin	10	Male	91-106	101.5 \pm 1.37 P 0.001
			10	Female	103-110	108.9 \pm 0.05
.01 ml	Pronotum	,,	10	Male	98-107	102.8 \pm 0.85 P 0.001
			10	Female	102-111	108.3 \pm 0.85
.01 ml	Wing base	,,	10	Male	98-107	102.8 \pm 0.85 P 0.001
			10	Female	102-111	108.3 \pm 0.85
.01 ml	Forefemur	,,	10	Male	95-100	97.8 \pm 0.51 P 0.001
			10	Female	103-111	107.6 \pm 0.88

TABLE 2. Effect of dieldrin (1%) on *Periplaneta americana*.

Amount of chemical applied	Place of application	% solution (in benzene)	No. of insects	Sex treated	Range of knockdown time (min)	Mean knock-down time
.01 ml	Hind thoracic sternite	1% dieldrin	10	Male	81-85	83.0 \pm 0.51 P 0.001
			10	Female	88-96	91.4 \pm 0.92
.01 ml	Pronotum	,,	10	Male	85-89	86.5 \pm 0.37 P 0.001
			10	Female	89-99	95.3 \pm 1.08
.01 ml	Wing base	,,	10	Male	85-89	86.8 \pm 0.41 P 0.001
			10	Female	90-100	95.3 \pm 1.13
.01 ml	Forefemur	,,	10	Male	70-74	72.2 \pm 0.35 P 0.001
			10	Female	75-82	78.7 \pm 0.83

The differential resistance to dieldrin formulations by different sexes of the animal may be attributed either to differential rate of detoxication in both the sexes or substantially low entry of dieldrin in females which may be due to differential total lipid content in the integument of

male and female as already observed by SAXENA & SAXENA (1981) or the slow movement of insecticide to the site of action within the insect body as it is checked at the site of action by the connective tissue sheath due to variable lipid content in the brain of males and females. The lipid

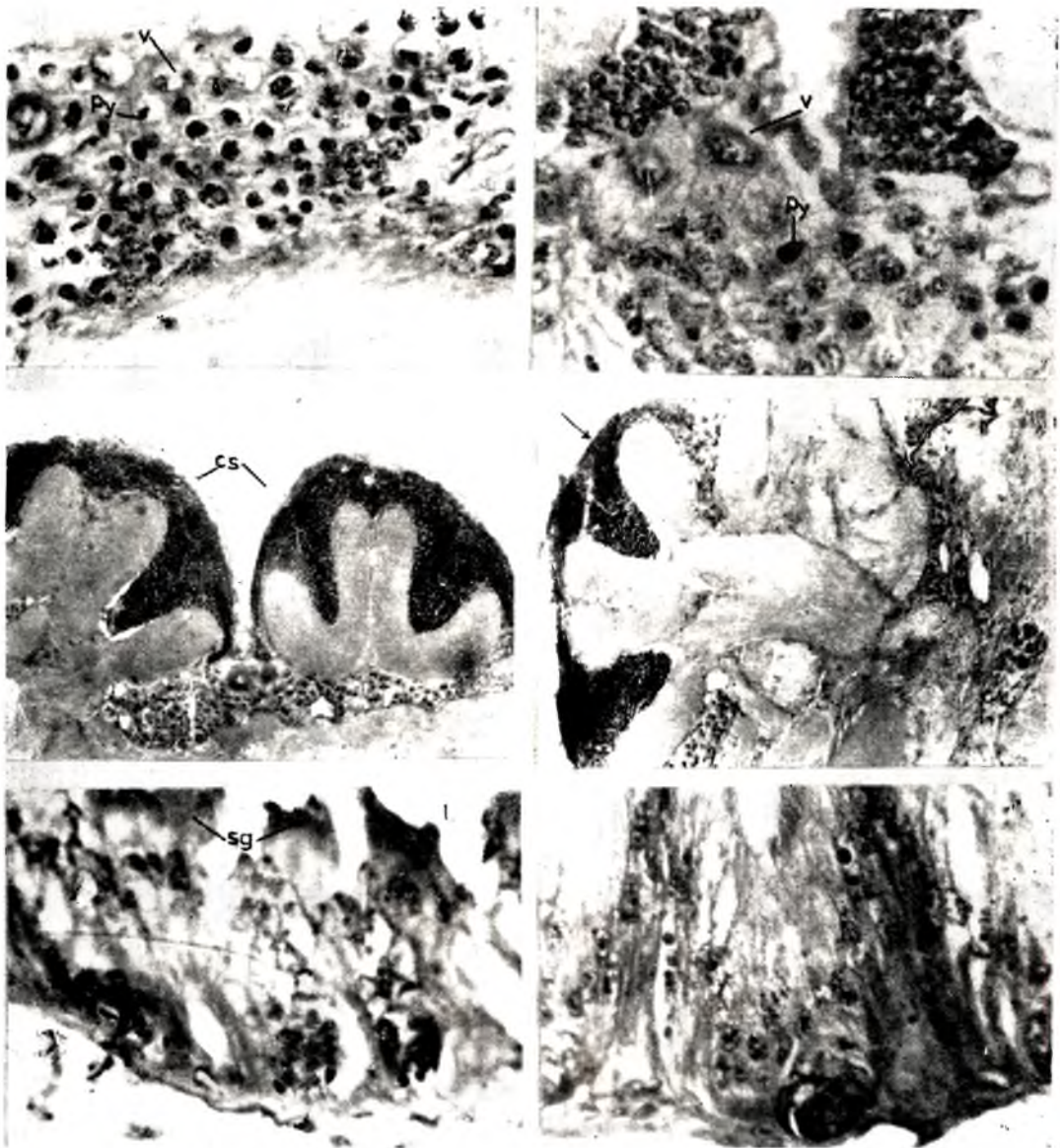


Fig. 1. (top left) Photomicrograph showing vacuolization (v) and pycnosis (py) in neuronal cells in males. $\times 400$. 2. (top right) Photomicrograph showing vacuolization (v) and pycnosis (py) in neuronal cells in female (note the intensity in pathological changes). $\times 400$. 3. (middle left) Photomicrograph showing separation of connective tissue sheath (cs) from the underlying glial cells in males. $\times 100$. 4. (middle right) Photomicrograph showing intact connective tissue sheath (arrow) from the underlying glial cells in females (Note the intensity). $\times 100$. 5. Photomicrograph (lower left) showing very much enhanced secretory activity by oozing of secretory globules (sg) into the lumen (l) in males. $\times 200$. 6. (lower right) Photomicrograph showing a little secretory activity in female- (note the intensity). $\times 200$.

TABLE 3. Effect of dieldrin (2%) on *Periplaneta americana*.

Amount of chemical applied	Place of application	soln solution (in benzene)	No. of insects	Sex treated	Range of knockdown time (min)	Mean knock-down time
.01 ml	Hind thoracic sternite	2% dieldrin	10	Male	78-83	78.8 \pm 0.67 P 0.001
			10	Female	82-90	85.7 \pm 0.96
.01 ml	Pronotum	..	10	Male	70-75	71.9 \pm 0.52 P 0.001
			10	Female	77-82	79.7 \pm 0.53
.01 ml	Wing base	..	10	Male	70-75	72.0 \pm 0.44 P 0.001
			10	Female	77-82	79.7 \pm 0.53
.01 ml	Forefemur	..	10	Male	68-73	69.9 \pm 0.64 P 0.001
			10	Female	72-79	75.7 \pm 0.85

being lesser in males as reported by SAXENA & SAXENA (1981). it promotes quick entry and ultimately quick response whereas in the brain of females since the lipid content is higher, the entry of dieldrin at the site of action is slow and thereby the effect manifested is delayed. Such a correlation between the quantity of lipid and absorbance of toxicant has been shown by O'BRIEN (1967a). It then becomes quite obvious that slower penetration of the insecticide can provide partial protection to the insect by lowering the internal concentration of the chemical.

The resistance in females may also be due to qualitative and quantitative difference in hydrocarbon fraction in the two sexes of *Periplaneta* as demonstrated by JACKSON (1970) and TRATIVITA & JACKSON (1970) who reported cis-9-tricosene in males and cis, cis-6:9-heptacosadiene in females as hydrocarbon fraction varying quantitatively in both the sexes. May be that due to the nature of these hydrocarbons, the penetration, of

dieldrin through the cuticle is different in the two sexes with the result, the response also varies in the two sexes, being quicker in males and delayed in females.

Resistance in females may be due to some fundamental insensitivity at the normal site of action which gains support by the findings of WINTERINGHAM (1960) who suggested an interference in the regulation of carbohydrate metabolism at glycerophosphate level.

Excitatory movements and jittering of legs exhibited by males earlier than females suggest that the latent period is longer in females than males, and support the observation of YAMASAKI & NARAHASHI (1959) that dieldrin poisoned nerve of the American cockroach shows spontaneous bursts of action potential, but in the nerve of resistant housefly there is much longer latent period between the application of dieldrin and the appearance of discharge.

The higher intensity of pathological changes in the midgut and brain of males

than females within the same time further supports that the females are more resistant as compared to males.

Acknowledgement:—One of the authors (PNS) is thankful to U G C, New Delhi for financing this investigation.

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FURTHER RECORDS OF TWO NEW SPECIES OF *DROSOPHILA* FROM ORISSA, INDIA

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The description of two new species of *Drosophila* from Orissa, *D. (Sophophora) microdenticulata* and *D. (Scaptodrosophila) bansadharae* are given. Their taxonomic status and relationships are discussed.

(Key words: new *Drosophila*)

INTRODUCTION

Orissa is also one of the several states in India whose Drosophilid faunal composition is yet to be furnished. Some recent collections in this region have however yielded several interesting species of Drosophilidae (Gupta, 1972; Dasgupta *et al.*, 1981; Panigrahy and Gupta (in press). This paper embodies the results of our further surveying studies carried out in this region.

1. *Drosophila microdenticulata* sp. nov.

Mean body length : 2.16 mm (♂); 2.38 mm (♀).

Head, ♂ and ♀ : Arista with 3 branches above and 1-2 below in addition to terminal fork. Antenna with second segment yellowish orange; third segment yellow. Frons including ocellar triangle pale brown. Orbitals in ratio of 6:3:8; anterior reclinate orbital thin, nearer to proclinate than posterior reclinate. Vibrissa strong, second oral thin, about one-third of vibrissa. Palpi pale, with one apical seta. Carina pale, narrow and high. Face and cheek yellowish brown, greatest width of cheek 1/6 greatest diameter of eye. Post-verticals long, ocellars of moderate length. Clypeus black. Eyes dark red.

Thorax, ♂ and ♀ : Acrostichal hairs regular, in 8 rows. Anterior scutellars convergent; posterior scutellars crossing each other. Anterior dorsocentral three-sevenths length of posterior dorsocentral; distance from anterior dorsocentral to posterior dorsocentrals about two-fifth the distance between two anterior dorsocentrals. Mesonotum and scutellum unicolorous, shiny yellow. Humeral two nearly equal. Thoracic pleura blackish brown. Sterno-index about 0.66.

Legs (Fig. 4) : Coxae and femorae of all legs prominently brown, tibiae and tarsal segments yellow. Fore femora with a posteromedial row of about 9-10 long bristles. Sex combs of male with two moderately thick claw-like black teeth on the distal end of foremetatarsus. Preapical on all three tibiae; apicals on first and second tibiae.

Wings, ♂ and ♀ (Fig. 5) : Hyaline. Mean length of wing 2.04 mm (♂); 2.22 mm (♀). Approximate indices : C-index 2.11; 4V-index 2.0; 4C-index 1.18; 5X-index 1.8.

Two small equal setae at the apex of first costal section; heavy setae near basal $\frac{1}{2}$ of third costal section. Halteres white.

Abdomen, ♂ and ♀: Abdominal tergites uniformly brown to black. Sternites brown.

Periphallic organs (Fig. 1): Epandrium yellow, broad and somewhat narrowing ventrally with 21 long bristles; upper portion with 5 and lower with 16 bristles. Surstyles triangular, with two sets of teeth—upper one with 2 moderately curved long black teeth; lower one with 4 sparsely placed, short, stout, black teeth in a row; and with a few fine seta medially and ventrally. Cerci large, with 21 upper large bristles and 8 closely placed small bristles ventrally.

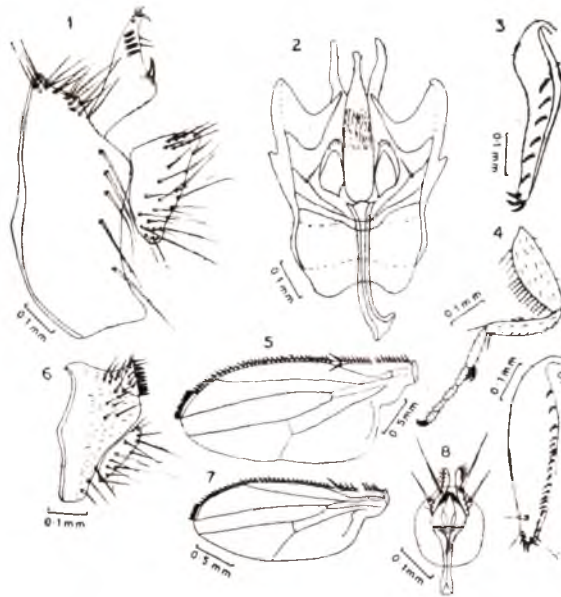
Phallic organs (Fig. 2): Aedeagus pale, non-bifid, medioventrally swollen and narrowing apically with dense hairs in middle. Basal apodeme of aedeagus nearly as long as aedeagus. Anterior gonapophyses broad and with 4 small sensilla

apically. Posterior gonapophyses large, narrow and dilated basally. Hypandrium with a pair of small submedian spines. Ventral fragma nearly quadrate and deeply incised ventrally.

Egg-guides (Fig. 3): Lobe yellow, elongate, with 6 equidistantly placed upper marginal teeth and 3 closely placed apical teeth. Basal isthmus short and narrow.

Holotype ♂ INDIA: ORISSA: Koraput district, Narayanpur, April 1981 (Panigrahy and Gupta).

Paratypes: 4 ♂♂, 6 ♀♀ same locality and collectors as **holotype**. Deposited in Department of Zoology, Banaras Hindu University, Varanasi, India and Department of Biology, Tokyo Metropolitan University, Tokyo, Japan.



Figs 1—5. *Drosophila microdentikulata* sp. nov. 1. Periphallic organs; 2. Phallic organs; 3. egg-guide; 4. Male fore leg; 5. Male wing. Figs. (6—9) *Drosophila bansadharæ* sp. nov. 6. Periphallic organs; 7. Male wing; 8. Phallic organs; 9. egg-guide.

Relationships: This species belongs to *denticulata* subgroup of the *melanogaster* species-group of the subgenus *Sophophora*. It closely resembles *D. denticulata* Bock and Wheeler in having fore femora with a postero-medial row of 9-10 long bristles and two claw like black teeth on the distal end of fore metatarsus; but distinctly differs from it in having pleura with no broad dark brown stripe (a broad dark longitudinal brown stripe with diffuse margins in *D. denticulata*); surstylus with distinct upper and lower sets of teeth (only 2 lower sets of teeth in *denticulata*); cerci with 8 closely placed bristles ventrally (with several short and pointed teeth in *denticulata*); aedeagus non-bifid (bifid in *denticulata*); male foremetatarsus with 2 moderately thick, claw-shaped teeth (unusually large claw-shaped teeth in *denticulata*).

Distribution: India.

2. *Drosophila bansadharae* sp. nov.

Mean body length : 1.99 mm (♂); 2.18 mm (♀).

Head ♂ and ♀: Arista with 4 branches above and 2 below in addition to terminal fork. Antennae with second segment brown; third segment pale yellow. Frons with a pale brown median stripe; margin along orbit yellow. Ocellar triangle dark brown. Orbitals in ratio of 6:2:8. Vibrissa present, second oral not differentiated. Palpi pale, with one apical seta and 1-2 fine setae. Carina brown, greatest width of cheek 1/7 greatest diameter of eye. Postverticals long. Ocellars very minute. Clypeus brown. Eyes bright red.

Thorax, ♂ and ♀: Acrostichal hairs regular, in 8 rows. Anterior scutellars nearly convergent; posterior scutellars crossing each other. Anterior dorsocentral half the length of posterior dorsocentral; distance from anterior dorsocen-

tral to posterior dorsocentral about half the distance between two anterior dorsocentrals. Mesonotum with a dark brown dorso-median stripe; basally swollen squarishly and with two brown dark spots on either side. Scutellum dark brown with whitish tip. Humerals two, equal. Thoracic pleura dark brown. Sterno-index about 0.6.

Legs: Pale brown, femorae and tibiae of all legs with dark bands. Pre-apicals on all three tibiae; apicals on first and second tibiae.

Wings, ♂ and ♀ (Fig. 2): Hyaline. Mean length of wing 1.88mm (♂); 2.02 mm (♀). Approximate indices: C-index 12.0; 4V-index 2.75; 4C-index 1.66, 5X-index 2.0. One seta at the apex of first costal section; heavy setae near basal 1/3 of third costal section. Halteres white.

Abdomen, ♂ and ♀: 1T Pale yellow, 2-3T with dark brown medially interrupted bands, 4-5T with broad and medially projected bands, 6T uniformly dark.

Periphallic organs (Fig. 1): Epanandrium yellowish-brown, pubescent, broadened below, projected at heel, with 3 bristles on upper half and 12 bristles on lower half. Surstylus small with 8 similar black teeth and 2 lower bristles arranged in a straight row on outer margin and with 3 dorso-median and a few setae ventrally. Cerci yellowish brown, with 14 bristles.

Phallic organs (Fig. 3): Aedeagus pale, short; bifid, apically narrowing and hirsute. Basal apodeme of aedeagus straight and longer than aedeagus. Anterior gonapophyses pale, narrow, finger like having several marginal sensilla, Hypandrium medially somewhat elevated, with 2 pairs of submedian spines, inner pair longer. Ventral fragma rounded distally.

Egg-guides (Fig. 4): Lobe yellow, elongate with 18 marginal teeth, 4 closely placed apical thick teeth and 2 discal bristles. Basal isthmus short and thick.

Holotype ♂, INDIA : ORISSA, Loraput district, Narayanpur, April 1981 (Panigrahy and Gupta).

Paratypes : 6♂♂, 12♀♀ same locality and collectors as holotype. Deposited in Department of Zoology, Banaras Hindu University, Varanasi, India and Department of Biology, Tokyo Metropolitan University, Tokyo, Japan.

Relationships : This species belongs to the subgenus *Scaptodrosophila*. It somewhat resembles *D. neomedleri* Gupta and Panigrahy (unpublished) in the details of male genital structures but distinctly differs from it in having mesonotum with a broad dark brown dorso-median stripe: basally swollen squarishly and with two brown dark spots on either side (no stripe and spots in *D. neomedleri*); surstylus with 8 similar black teeth arranged in a row (9 dissimilar black teeth in *neomedleri*); hypandrium with 2 pairs submedian

spines of moderate length (2 pairs of unusually long spines in *neomedleri*); egg-guide with 18 marginal and 4 apical teeth (6 marginal and 3 apical teeth in *neomedleri*).

Distribution : India

Acknowledgements:—The authors are thankful to Dr. T. Okada, Emeritus Professor, Department of Biology, Tokyo Metropolitan University, Tokyo, Japan for his help in confirming the identifications and to the Head of the Zoology Department for facilities. One of us (KKP) is thankful to UGC for awarding the Teacher fellowship under the faculty improvement programme.

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NEW FALSE SPIDER MITES (TENUIPALPIDAE : ACARI) FROM TAMILNADU

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(Received 15 January 1982)

The paper presents the descriptions and figures of five new false spider mites, viz. *Tenuipalpus vriddhagiriensis*, sp. nov., *T. trifoliatae*, sp. nov., *Dolichotetranychus tenellae*, sp. nov., *D. repenae*, sp. nov. and *D. elatariae*, sp. nov.

(Key words: Acarina, Tenuipalpidae, taxonomy, new species, India)

In the course of collection and study of phytophagous mites in Tamilnadu, five species of false spider mites which are new to science were discovered. These mites are described, adequately sketched and presented below. The types and paratypes are deposited in the Department of Agricultural Entomology Collections, Tamilnadu Agricultural University, Coimbatore, India (TNAU).

1. *Tenuipalpus vriddhagiriensis*, sp. nov. (Figs. 1 to 3)

Female: Red in colour, 270¹ long including rostrum; 140 wide; rostrum 35 long reaching nearly the length of femur I; palpus 3 segmented, first segment 2.5 long; second segment 7 long with a barbed seta at its anterior end, 11 long; third segment 2.5 long with a spine 6 long at its tip.

Rostral shield broadly bifurcate, reaching just the base of femur I, propodosoma with a pattern of wavy lines; three pairs of dorsal propodosomal setae; DP I, 8 long; DP II, 10 long and DP III, 20 long. Hysterosoma with a pattern of

wavy lines; 3 pairs dorsocentrals, DH I, 7 long; DH II, 6 long; DH III, 7 long; one pair of humerals, 8 long; six pairs of dorsolaterals, DLH I, 7 long; DLH II, 7 long; DLH III, 8 long; DLH IV, 10 long; DLH V, 110 long, flagellate; DLH VI, 6 long; all setae on dorsum are lanceolate and serrate.

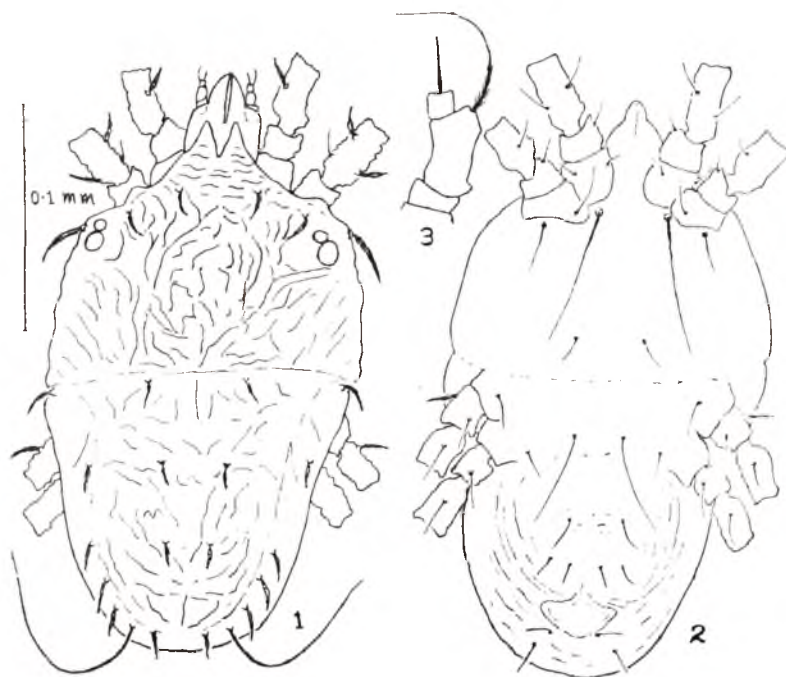
Venter with one pair of medioventral propodosomals, 115 long near the forecoxal base; a pair of anterior medioventral metapodosomals, 14 long; two pairs of posterior medioventral metapodosomals, the inner pair 45 long; the outer pair 35 long; a pair of medioventral setae 1.5 long on ventral plate; two pairs of genital setae and pairs of anal setae; all setae on venter simple.

Setae on legs I to IV: Coxae, 2, 2, 1, 1; trochanter, 1,1,2,1; femora, 3,4,2,1; genua, 1,1,0,0; tibiae, 3,3,2,2; tarsi, 6 (1), 6(1), 4,4; setae on dorsal side of the legs serrate while those on ventral side are simple.;

Male: Not known.

Types: A holotype slide with four females and 3 paratype slides, each with four females; India, Tamilnadu, Vriddhachalam, ex unidentified road side

¹ All measurements, unless otherwise stated, are in μ m.



Tenuipalpus vridhagiriensis sp. nov. (Figs. 1—3). 1. Dorsal view of mite; 2. Ventral view of mite; 3. Palpus.

hedge plant, 4.viii.1981, coll. M. Mohanasundaram (No. 61) (TNAU).

Remarks: This species resembles *Tenuipalpus indicus* Maninder and Ghai (1978) but could be differentiated from it by the palpus which is characteristic in shape; dorsal pattern of lines and the measurements.

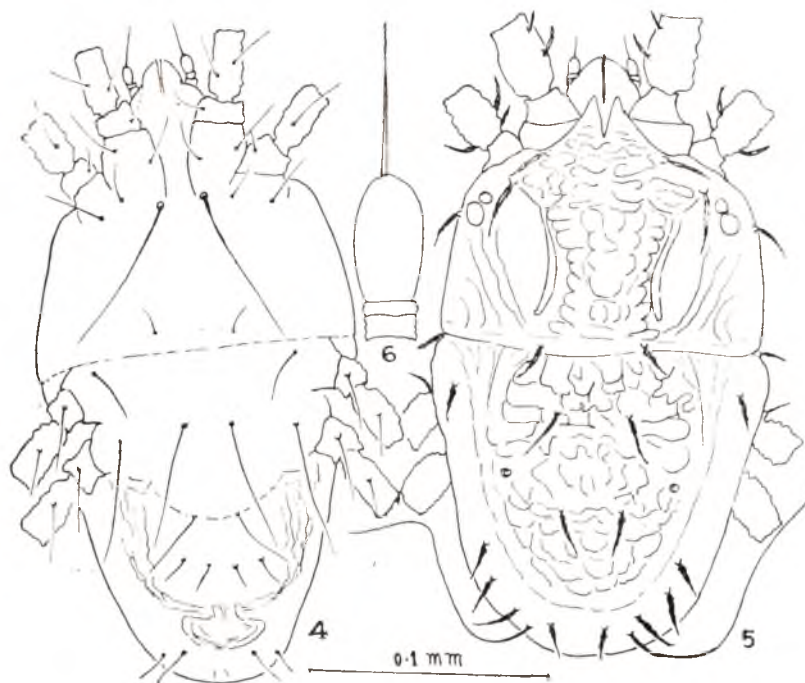
2. *Tenuipalpus trifoliatae*, sp. nov. (Figs. 4 to 6)

Female: Red in colour, 260 long including rostrum, 135 wide; rostrum 30 long, reaching nearly half the length of femur I, palpus 3 segmented; segment I, 3 long; segment II, 1 long; segment III oval shaped, 6 long with a terminal spine 15 long.

Rostral shield broadly bifurcate, reaching just the base of femur I, propo-

dosoma with a pattern of wavy lines in the middle bound by invaginations on either side; sides of propodosoma with diagonal lines; three pairs of dorsal propodosomal setae, DP I, 12 long; DP II 25 long; DP III, 20 long. Hysterosoma with a pattern of wavy lines: three pairs of dorsocentrals DH I, 15 long; DH II, 17 long; DH III, 12 long; one pair of humerals, 10 long; six pairs of dorsolaterals: DLH: I, 9 long; DLH II, 9 long; DLH III, 11 long; DLH IV, 12 long; DLH V, 105 long, flagellate: DLH VI, 9 long; all setae on dorsum are lanceolate and serrate.

Venter with one pair of medioventral propodosomals, 55 long near forecoxal base; a pair of anterior medioventral metapodosomals, 20 long; two pairs of posterior medioventral metapodosomals,



Tenuipalpus trifoliatae sp. nov. (Figs. 4 to 6). 4. Ventral view of mite; 5. Dorsal view of mite; 6. Palpus.

inner pair 55 long, outer pair 30 long; a pair of medioventral setae 20 long on ventral plate, two pairs of genital setae and two pairs of anal setae: all setae on venter simple.

Setae on legs I to IV: Coxae, 2,2,1,1; trochanter, 1,1,2,1; femore, 4,3,2,1; genua, 3,3,0,0; tibiae, 4,4,3,3; tarsi, 6(1), 6(1) 4,4. Setae on dorsal aspect of the legs serrate while those on ventral aspect are simple.

Male: Not known.

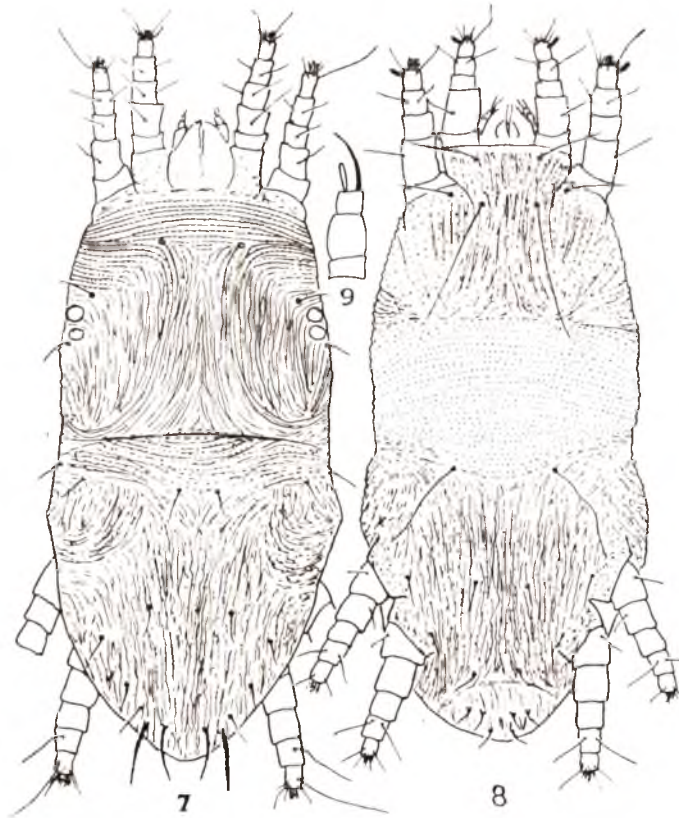
Types: A holotype slide with four females and 5 paratype slides, four females each; India, Tamilnadu, Vriddhachalam, ex-unidentified thorny hedge plant with small trifoliolate leaves, 4. viii. 1981, coll. M. Mohanasundaram (No. 62) (TNAU).

Remarks: This species resembles *Tenuipalpus mkuziensis* Mayer (1979) in its dorsal pattern, but could be differentiated from it by the unique palpus with a single spine at its distal end apart from the measurements of the body and setae.

3. *Dolichotetranychus tenellae*, sp. nov. (Figs. 7 to 9).

Female: Red in colour, dorsum provided with tuberculate longitudinal and cross striations: 365—375 long including gnathosoma, 150 wide. Gnathosoma 55 long, reaching upto half the length of femur I, palpus 3 segmented with a pair of setae in the terminal segment.

Dorsum: The propodosoma and hysterosoma provided with fine tuberculate striations; the dorsal body setae are setiform; three pairs of propodosomal setae,



Dolichotetranychus tenellae, sp. nov. (Figs. 7 to 9). 7. Dorsal view of mite; 8. Ventral view of mite; 9. Palpus.

DP I, 10 long, 42 away from each other; DP II, 10 long; DP III, 16 long; hysterosoma with two pairs of dorsocentrals; DH I, 6 long; DH II, 5 long; one pair of humerals, 9 long; one pair of dorso-sublaterals 12 long; 5 pairs of dorsolaterals. DLH I, 6 long; DLH II, 5 long; DLH III, 8 long; DLH IV, 40 long; DLH V, 16 long; the last two setae being rough and thick.

Venter: The anterior pair or medioventral setae are flagelliform, 80 long; a pair of anterior medioventral metapodosomals, 40 long; 3 pairs of posterior medioventral metapodosomals 15 long;

a pair of medioventral pregenital setae 4 long; two pairs of genital setae and one pair of anal setae; all setae on venter simple.

Setae on legs I to IV: Coxae, 1.1.1, 1.1; trochanter, 0.0.1.0; femora, 2.2.2.1; genua, 2.1.0.0; tibiae, 4.4.3.3; tarsi, 5(1), 5(1), 6.6; tarsal claw comb like.

Male: Red in colour, body 345 long including gnathosoma and genital armature, 115 wide; the body tapering towards the rear end. Dorsal propodosoma with crosswise striations, mesopodosoma with longitudinal striations, humeral region with crosswise striations; metapodosoma

with crosswise striations in the centre and longitudinal striations on the sides, caudal end tapering with longitudinal striations upto the genital setae and thereafter with cross striations: dorsal and ventral setation as in the female.

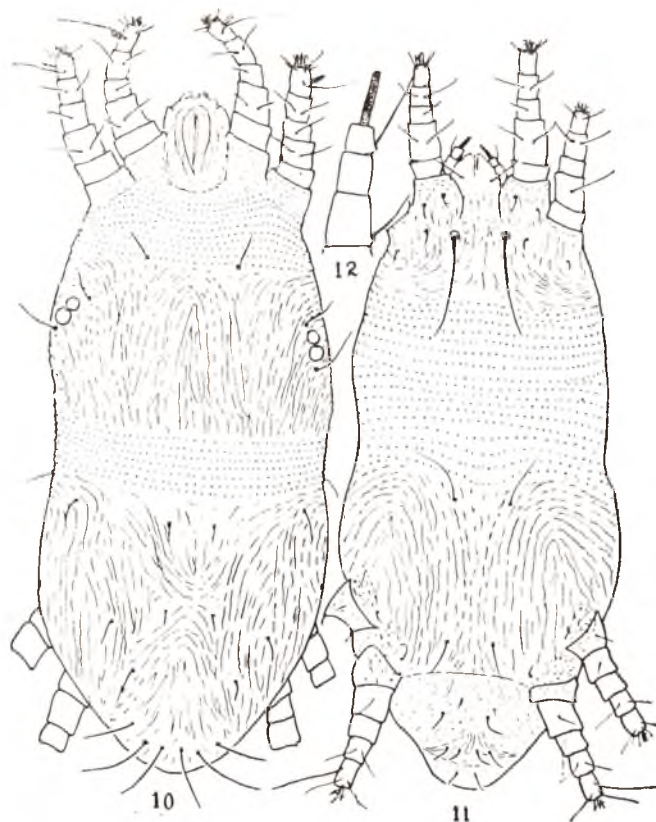
Types: A holotype slide with two males and two females: and 3 paratype slides each with two males and two females: India, Tamilnadu, Vridhachalam ex *Eragrostis tenella* (Gramineae) 4.viii. 1981. Coll. M.Mohanasundaram (No. 63) (TNAU).

Remarks: This species belongs to the *D. carnea* group having one pair of

anal setae and two pairs of genital setae. It is differentiated from *D. carnea* (Banks) (Pritchard & Baker, 1951) by its shorter dorsal seta on femur II and different male genital structure: from *D. macar* Baker & Pritchard (1956) by the pregenital setae placed closer to each other: from *D. vanderghooti* (Oudemans) by the tarsi I and II of male each with one solinidion and from *D. alpinus* Meyer (1979) by the longer medioventral setae.

4. *Dolichotetranychus repenae*: sp. nov. (Figs. 10 to 12)

Female: Red in colour, dorsum with tuberculate longitudinal and cross striations: 350-360 long including gnathosoma;



Dolichotetranychus repenae, sp. nov. (Figs. 10 to 12). 10. Dorsal view of mite; 11. Ventral view of mite; 12. Palpus.

140 wide. Gnathosoma 50 long, almost reaching the distal end of femur I, with a pair of setae on the ventral side; palpus 3 segmented, basal segment with a seta at its base pointing sideways; second segment with a seta at its distal end on the dorsal aspect and the third segment with a thick solinidion at its tip, as long as the segment.

Dorsum: Propodosoma with crosswise tuberculate striations in the anterior end and longitudinal tuberculate striations behind upto the humeral angle intervened by crosswise tuberculate striations upto the first dorsocentral hysterosomal setae and with diagonal and zig-zag striations posteriorly. The dorsal body setae are setiform: {three pairs of propodosomal setae DP I, 8 long; DP II, 15 long; DP III, 18 long; hysterosoma with two pairs of dorsocentrals DH I, 5 long; DH II, 4 long; one pair of humerals, 6 long, one pair of dorsosublateral 10 long; 5 pairs of dorsolateral setae, DLH I and II 5 long each, nearly in sublateral positions, DLH III, 17 long; DLH IV, 25 long; DLH V, 15 long, the last three setae coarse and thick.

Venter: The anterior pair of medioventral setae are flagelliform 35 long; a pair of anterior medioventral metapodosomals 35 long, a pair of posterior medioventral metapodosomals, 10 long, a pair of pregenital setae 3 long, 28 apart from each other; genital aperture 35 wide, two pairs of genital setae and one pair of anal setae; all setae on venter simple.

Setae on legs I to IV: Coxae, 2,2,2, 1,1; trochanter, 0,0,1,0; femora, 4,3,2,1; genua, 2,1,1,0,0; tibiae, 4,4,3,3; tarsus, 6 (1), 6(1), 4,4, tarsal claws comb like.

Male: Not known

Types: A holotype slide with four

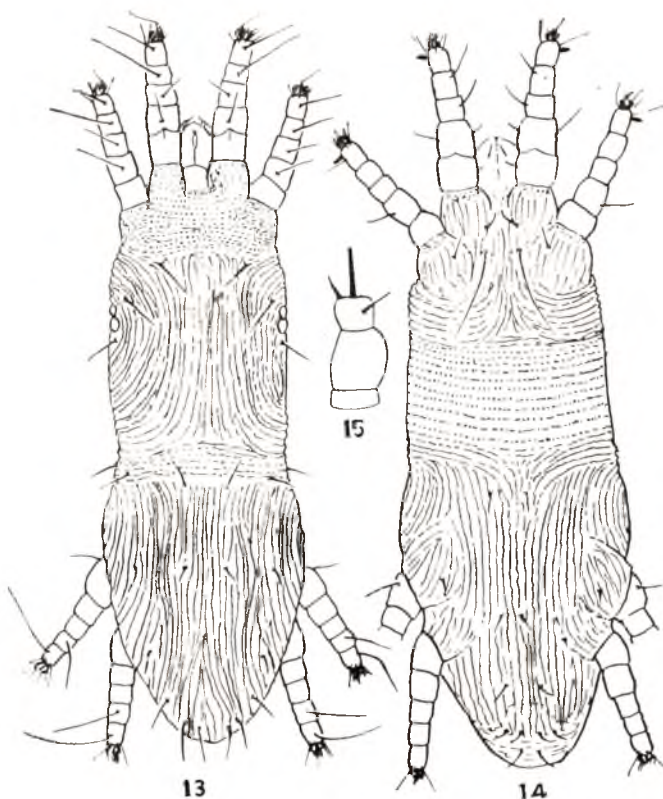
females and 3 paratype slides, each with four females; India, Tamilnadu, Pennadam, ex *Panicum repens* Linn. (Gramineae), 4.viii.1981. Coll. M. Mohanasundaram (No. 67) (TNAU).

Remarks: This species also belongs to *D. carnea* group having one pair of anal setae and 2 pairs of genital setae. It is differentiated from the closest species of this group *D. carnea* by its femur I with a long dorsal seta almost reaching the distal margin of tibia; femur II with a pair of short dorsal setae as long as the segment; tarsi I and II having one solinidion each on the lateral aspect, rostrum with a pair of setae on the ventral side, palpus with the basal segment with a seta at its base pointing sideways, second segment with a seta at its distal end on the dorsal aspect and the third segment with a thick solinidion in the tip as long as the second segment, apart from the striation pattern.

5. *Dolichotetranychus clatariae* sp. nov. (Figs. 13—15)

Female: Red in colour, dorsum provided with tuberculate longitudinal and cross striations, 460-470 long including gnathosoma, 165 wide. Gnathosoma 70 long, reaching upto the middle of the femur I, palpus 3 segmented, with a seta on the dorsal aspect and a thick spine at the tip of the 3rd segment, gnathosoma with a pair of short ventral setae.

Dorsum: The propodosoma and hysterosoma provided with five tuberculate striations, the dorsal body setae are thick and rough; three pairs of propodosomal setae, DP I, 22 long; 60 away from each other, DP II, 20 long; DP III 12 long on the sides, hysterosoma with two pairs of dorsocentrals, DH I, 13 long, 28 away from each other DH II, 6 long, 35 away from each other; one pair of humerals



Dolichotetranychus elaturiae sp. nov. (Figs. 13 to 15). 13. Dorsal view of mite; 14. Ventral view of mite; 15. Palpus.

11 long one pair of dorsosublateral 12 long; five pairs of dorsolaterals, DLH I, 7 long; DLH II, 7 long; DLH III, 12 long; DLH IV, 22 long; DLH V, 20 long.

Venter: The anterior pair of medioventral setae are flagelliform, 70 long; a pair of anterior medioventral metapodosomals, 5, long 34 apart from each other, a pair of posterior medioventral metapodosomals, 5 long; 15 away from each other, a pair of medioventral pregenital setae, 3 long and 25 apart; two pairs of genital setae measuring about 3 each and one pair of anal setae measuring 2 each all setae on venter simple.

Setae on legs I to IV: Coxae, 1.1.1.0; trochanter, 1.1.1.0; femore, 4.4.2.1; genua 2.1.0.0; tibia, 4.4.3.3; tarsi 6(1), 6(1), 5.5, tarsal claws with 3 sets of hooked spines each.

Male: Red in colour, body 475 long including gnathosoma and genital armature; 140 wide; the body tapering towards the rear end. Dorsal propodosoma with crosswise striations, mesopodosoma with longitudinal striation, humeral, region with cross striations, metapodosoma with longitudinal scorings, hysterosoma tapering in a conical form, with cross striations in the anterior three-fourths and the

posterior portion with thick granules, distal end with paired spine like genital armature: dorsal and ventral setation as in the female.

Types: A holotype slide with two males and two females and 10 paratype slides each with two males and two females, India, Karnataka, Dharwad, ex *Elataria cardamomi* (Zingiberaceae) 24.ix. 1981, Coll. Puttasamy (No. 70) (TNAU).

Remarks: This species also belongs to the *D.carnea* group, having one pair of anal setae and two pairs genital setae. It resembles *D. vandergooti* (Oudemans) in its anterior pair of medioventral setae 4-5 times as long as the short posterior pair, but differentiated from it by the shorter dorsal seta on femur II, the structure of the palpus, setation on the legs and the measurements.

Acknowledgement: Thanks are due to Dr. E. W. Baker, USDA, for the generous supply of reprints on Tenuipalpidae and for the suggestions, and to Dr. Magdalena K. P. Smith Meyer, Plant Protection Research Institute, Pretoria, South Africa for the help rendered for this study.

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HISTOPATHOLOGY OF THE ARMYWORM, *MYTHIMNA* (*PSEUDALETIA*) *SEPARATA* (WALKER) (LEPIDOPTERA : NOCTUIDAE) INFECTED WITH NUCLEAR POLYHEDROSIS VIRUS

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(Received 13 November 1982)

The histopathology of nuclear polyhedrosis of the armyworm *Mythimna* (*Pseudaletia*) *separata*, notorious agricultural pest infected with two different viral concentrations i. e., 2.5×10^6 and 5×10^6 PIBs/ml, was observed in a series of 5th instar larvae collected at 24 hour intervals. The procedures for sections and staining have been described. Initially and principally, the nuclei of fat body, hypodermis, hypodermal gland and tracheal matrix were the target tissues for replication of the polyhedrosis virus. Later those of wing buds, imaginal discs, ovary, testes, silk gland, Malpighian tubules and, sarcolemma revealed heavy infection. Finally, polyhedral inclusion bodies (PIBs) were also observed even in the nuclei of neurilemma, frontal ganglion, thoracic ganglion and cerebral complex. It was astonishing that quite often the epithelial layers of foregut, midgut and hindgut were infected.

(Key words: histopathology, nuclear polyhedrosis virus, *Mythimna separata*, armyworm)

INTRODUCTION

The armyworm *Mythimna* (*Pseudaletia*) *separata* (WALKER) is a notorious agricultural pest in India (FLETCHER, 1917), other Asian countries, USSR, Australia, New-zealand and Pacific Islands (CIE, 1967). Nuclear polyhedrosis viruses (NPV) frequently occur in lepidopteran insects. NEELGUND & MATHAD (1972) were the first to describe NPV disease of the armyworm. The virus is of multiple embedded type belonging to the genus *Baculovirus*. It has been demonstrated that the NPV possesses adequate potential to control its host both in the laboratory and field (NEELGUND, 1975).

Although this nuclear polyhedrosis has been studied with regard to its signs

and symptoms (NEELGUND & MATHAD, 1972), so far no elaborate histopathological study has been undertaken. We have, therefore, conducted such a study which would provide the sequence of infection, relative susceptibility of various tissues to infection and dissemination of PIBs through host's death. These fundamental investigations would provide a sound background to manipulate the conditions in the host's body and induce stress leading to the preponement of death. Consequently, efficacy in viral control of the armyworm would be also increased. The aim of the present work is to report and discuss the results of histopathological investigations of the armyworm artificially infected with NPV in the laboratory.

MATERIALS AND METHODS

The armyworm larvae were obtained from field collection and reared in the laboratory on artificial diet (NEELGUND, 1975). The NPV used in this study was harvested from a laboratory culture of the armyworm. Healthy 15-day-old fifth instar larvae, having uniform body size, were isolated from the laboratory stocks for experimentation. The larvae were treated by applying 0.01 ml of 2.5×10^6 and 5×10^6 PIBs/ml suspension to the surface of artificial diet. Control larvae were fed the same volume of sterile distilled water mixed with the artificial diet. The inoculated armyworms were sacrificed at intervals of 1, 2, 3 and 4 days and fixed for microtomy.

Histological techniques

The larvae were killed in hot Bouin Duboscq fixative. After 10 minutes each larva was cut transversely into three parts which were transferred to fresh fixative at room temperature and fixed *in vacuo* for 21–24 hr. The fixed materials were prepared for sectioning by passing them through ethyl alcohol, methyl benzoate, benzene series and paraffin (MP 60°C). Transverse sections were cut at 4 μ and stained according to modified Azan technique (HAMM, 1966).

RESULTS AND DISCUSSION

Signs, symptoms and gross pathology

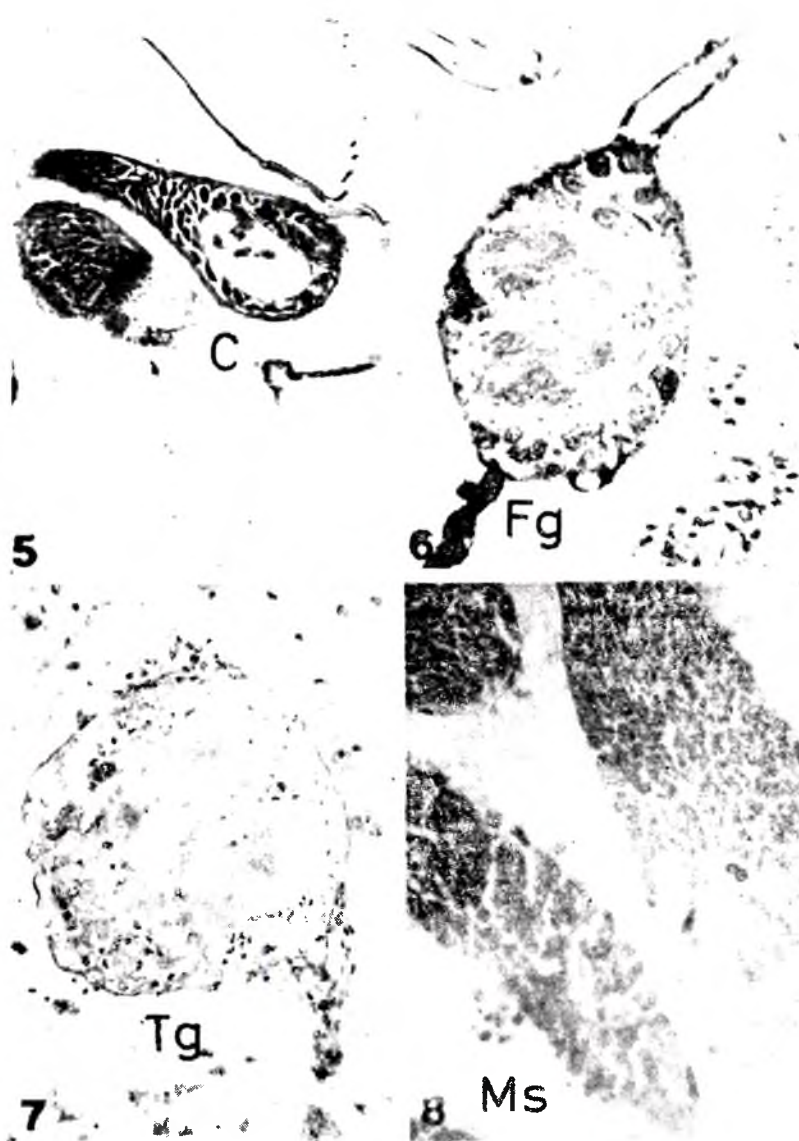
Diseased larvae were easily recognised by the opaque white appearance of the integument. Then as the external symptoms progressed, a few pale spots on the posterodorsal surface gradually extended on either side of mid-dorsal line throughout the body. Later, the larvae lost their appetite and ceased feeding. The infected larvae could move only their head and exhibited the tendency of migrating to the tops of rearing jars. Before death, the larvae often hung by their prolegs from the wall of the rearing container. Such symptoms were noticed usually 4–5 days after the polyhedral ingestion. Finally, after death the body bursts open and PIBs are disseminated to infect healthy larvae.

Histopathology

In the larvae treated with NPV, fat body appeared to be the first kind of tissue infected. Initially and principally, the nuclei of fat body, hypodermis, hypodermal gland and tracheal matrix were the target tissues for replication of the polyhedrosis virus. In addition, the nuclei of imaginal disc (Fig. 1), wing buds (Fig. 2), hypodermal gland (Fig. 4), silk gland (Fig. 9), tracheal matrix (Fig. 11), Malpighian tubules (Fig. 10), and sarcolemma (Fig. 8) showed heavy infection quite frequently. Moderate infection was very distinct in the nuclei of cerebral complex (Fig. 5), frontal ganglion (Fig. 6) and thoracic ganglion (Fig. 7) at 72 hr post-treatment. In other tissues the PIBs were observed during the period ranging from 48 hr to 96 hr. Immediately, after 24 hr post-treatment minute distinct PIBs were noticed in the midgut lumen (Fig. 14). In the present study, surprisingly the epithelial layers of foregut, midgut and hindgut showed clear infection even at early stages of post-infection (Figs. 13–15). Moreover, cells of the ovary (Fig. 16) and testes (Fig. 17) showed PIBs in advanced stages of infection. A distinct group of ordinary fat body cells (Fig. 12), which were found very close to hypodermis revealed clear infection at 48 hr. Typically, the fat body was heavily infected having most of its nuclei packed with mature polyhedra. At 120 hr besides these tissues, other tissues of hemocoel were found to contain mature polyhedra in their nuclei. The infection of all these tissues was uniform irrespective of two viral concentrations at different intervals. No infected cells were found in sections of the control (untreated) larvae and the nuclei in such cells appeared normal and relatively small.



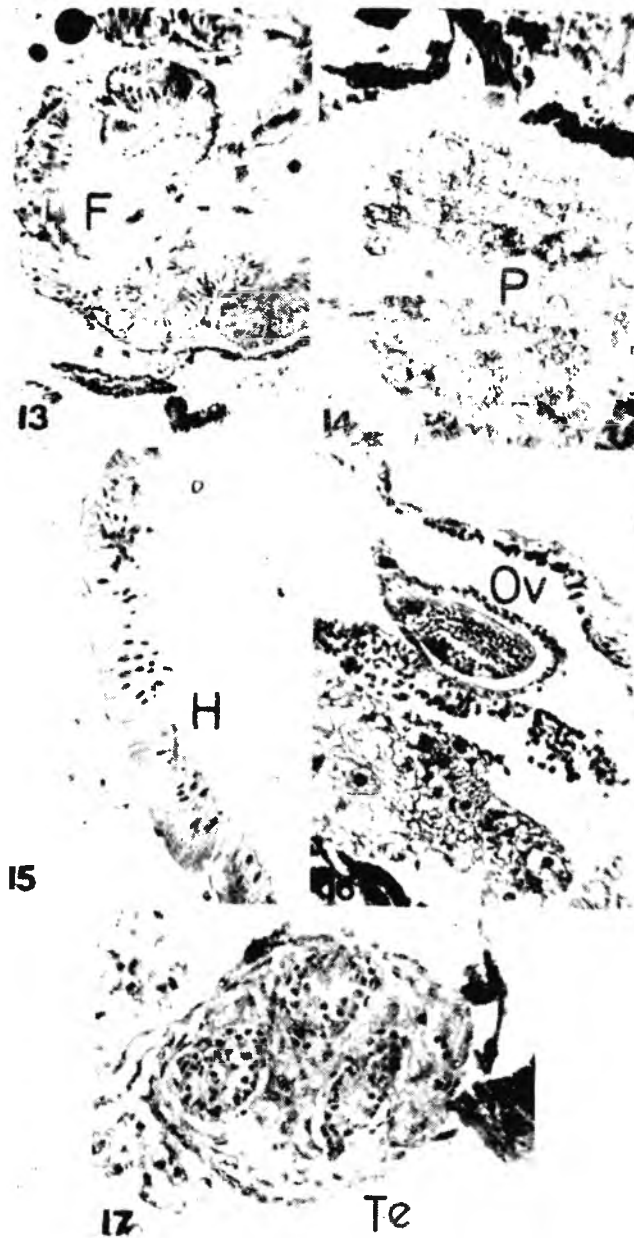
Figs. 1—4. Cross sections showing infection of the following with nuclear polyhedrosis virus of *M. (P.) separata*. 1, imaginal disc for wing; 540 \times . W. wing bud; 510 \times . S. Spiracle; 550 \times . Hg. hypodermal gland; 500 \times .



Figs. 5—8. Cross sections showing infection of following with nuclear polyhedrosis virus of *M. (P.) separata*. C, portion of cerebral complex; 540 \times . Fg, frontal ganglion; 540 \times . Tg, thoracic ganglion; 520 \times . Ms, muscles; 520 \times .



Figs. 9-12. Cross sections showing infection of the following with nuclear polyhedrosis virus *M. (P.) separata*. Sg, silk gland 520 \times . M, Malpighian tubule; 500 \times . T, tracheal matrix; 500 \times . O, ordinary fat body cells; 500 \times .



Figs. 13—17. Cross sections showing infection of the following with nuclear polyhedrosis virus of *M. (P.) separata*. F, foregut epithelium; 400 \times . P, presence of PIBs in the midgut lumen at 24 hr postinfection; 450 \times . H, hindgut epithelium; 400 \times . Ov, ovary; 450 \times . Te, testis; 600 \times .

DISCUSSION

In general, the gross pathology and histopathology of the armyworm *M. (P.) separata* appears to be typical of nuclear polyhedrosis of other Lepidoptera. The fat body, hypodermis, tracheal matrix, Malpighian tubules, silk glands, imaginal discs, gonads, hypodermal glands, foregut, midgut and hindgut were obviously infected.

Infection of the nuclei of fat body, hypodermis and tracheal matrix of the armyworm was similar to the findings of DRAKE & MCEWEN (1959) in *Trichoplusia ni*. HEIMPEL & ADAMS (1966) reported a new nuclear polyhedrosis of *T. ni* that infected the midgut epithelium, fat body and tracheal matrix. Our results differed from them in that they showed the infection of midgut epithelium first, followed by other tissues of the haemocoel. In the present investigation fat body, hypodermis, hypodermal gland and tracheal matrix were the principal target tissues for replication of the polyhedrosis virus. This phenomenon is explained by ADAM'S (1954) suggestion that the role of host cell polysaccharides is solely that of furnishing a chemically specific site to which the virus particles become attached as a first step in the infection cycle. The insect fat body, needless to say, is the storage organ for carbohydrates.

However, infection of the sarcolemma, neurilemma, frontal ganglion, silk glands, Malpighian tubules and wing buds is in conformity with the findings of MATHAD, SPLITTSTOESSER & MCEWEN (1968) in *T. ni*.

Similarly, ARUGA *et al* (1957) reported nuclear polyhedrosis infection in the silk gland of *Bombyx mori* and TANADA (1954) recorded polyhedra in the

nucleus of cells lining the Malpighian tubules and digestive tract of *Pieris rapae*. Later, TANADA (1959) observed the infected muscle cells and midgut epithelium in *Pseudaletia unipuncta*. BENZ (1963) also listed nerve sheath, ganglion cells, muscle cells and pericardial cells among the tissues infected by the nuclear polyhedrosis of *Malacosoma alpicola*.

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TWO NEW SPECIES OF TENUIPALPUS (TENUIPALPIDAE : ACARI) FROM TAMILNADU

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(Received 15 January 1982)

Two new species of *Tenuipalpus* viz., *Tenuipalpus acuminatae* and *Tenuipalpus mallotae* from Tamilnadu are described in this paper.

(Key words: Acarina, new *Tenuipalpus* from Tamilnadu)

During the survey of Tenuipalpid mites from South India, two new species of *Tenuipalpus* were discovered. They have been adequately studied, described and figured in this paper. The types and paratypes have been deposited in the Department of Agricultural Entomology collections, Tamilnadu Agricultural University, Coimbatore 641003, India.

1. *Tenuipalpus acuminatae*. sp. nov. (Figs. 1—5)

Female: Flat, dirty white with dark markings, 310¹ long including rostrum, 205 wide, rostrum 45 long, reaching just above the base of femur I; palpus 3 segmented; first segment 3 long; second segment 12 long, bulged with a hairy seta 15 long in the anterior half; third segment, 3 long with a 7 long spine at the tip.

Propodosoma with faint crosswise markings; three pairs of dorsal propodosomal setae; DP I, 5 long; DP II, 5 long; and DP III, 35 long. Hysterosoma with cross lines; two pairs of dorsocentrals DH I, 6 long; DH II, 6 long; one pair of humerals, 10 long, 5 pairs of dorsolaterals, DLH I, 11 long; DLH II, 22 long;

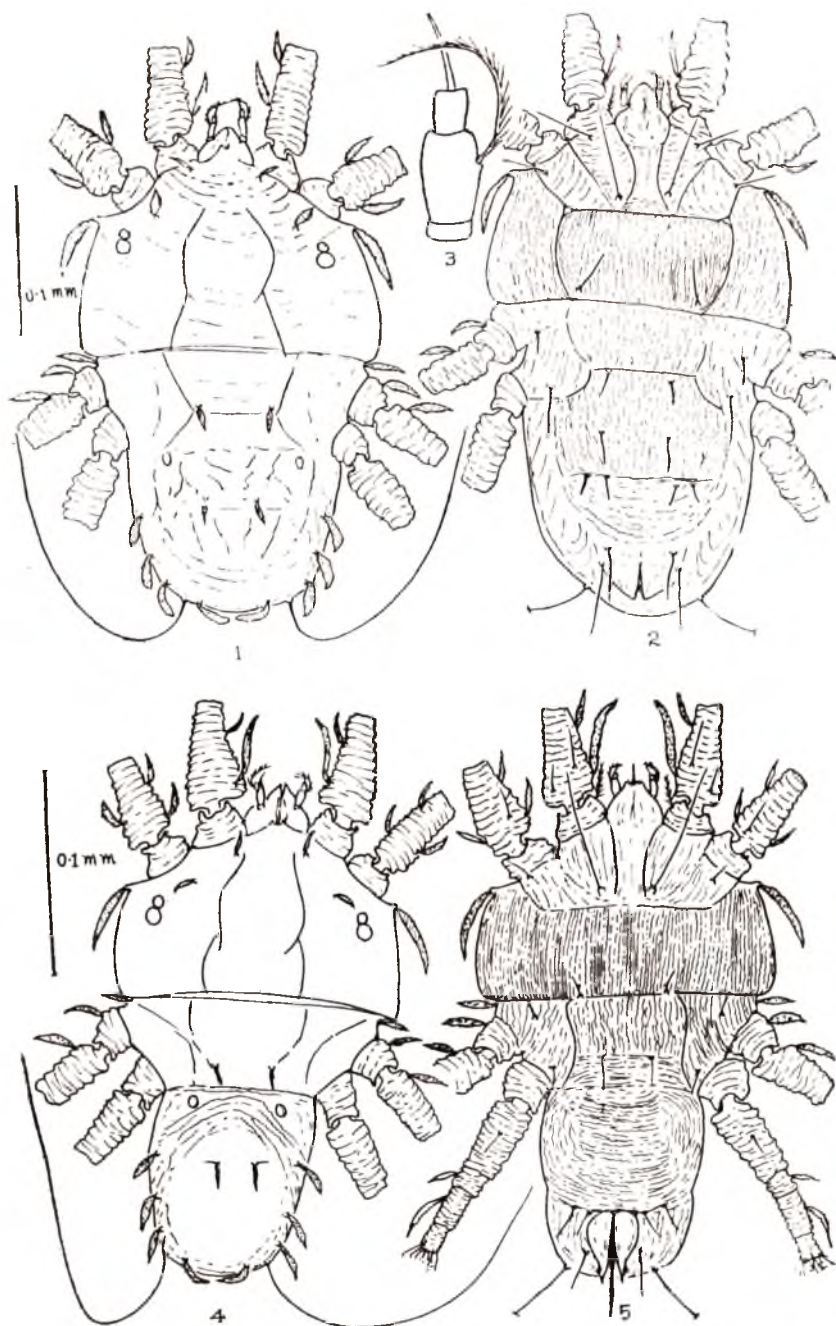
DLH III, 22 long; DLH IV, flagellate 250 long; DLH V, 22 long; all setae on dorsum are lanceolate and serrate.

Venter with fine wavy striations, with a pair of anterior medioventral propodosomals, 85 long at the base of forecoxae; a pair of anterior medioventral metapodosomals just above the humeral line, 10 long; one pair of posterior medioventral metapodosomals 10 long; one pair of pregenitals 15 long; two pairs of genital setae 15 and 18 long; two pairs of anal setae, inner pair 8 long and outer pair 25 long, all setae on venter are simple.

Setae on legs I to IV: coxae, 2,1,1,1; trochanter, 1,0,1,0; femora, 2,3,1,0; genua, 2,2,1,1; tibiae, 4,4,2,2; tarsi 6(1), 6(1), 5,5. Setae on dorsal and lateral aspects of the legs are lanceolate and serrate, while those on ventral side, simple.

Male: Flat, dirty white with dark markings 260 long, 155 wide; dorsal setation similar to female; ventral setation with reduced number of setae; one pair of medioventral metapodosomals and one pair of anal setae less than in the female. Dorsum with faint thick cross striations while the venter with fine wavy striations.

* All measurements are in μ m, unless otherwise stated.



Figs. 1—5. *Tenuipalpus acuminatae*, sp. nov. 1. Dorsal view of female; 2. Ventral view of female; 3. Palpus; 4. Dorsal view of male; 5. Ventral view of male.

Types: A **holotype** slide with four females; and six **paratype** slides with two males and two females each; INDIA: TAMIL NADU, South Arcot, Vanniarpalayam, ex *Teliacora acuminata* Miers (Menispermaceae) 29.x.1981, Coll. M. Mohanasundaram (No. 71) TNAU.

Remarks: This species has two pairs of dorsocentral setae and 3 segmented palpus and hence belongs to *trisetosus* group and is quite close to *T. transvalensis* Meyer (1979), but could be differentiated from it by the dorsal and ventral striation patterns; hairy setae on the second segment of palpus; longer third dorsal propodosomal seta; and shorter posterior medioventral setae apart from other measurements.

2. *Tenuipalpus mallotae*, sp. nov. (Figs. 6–10)

Female: Dirty white in colour with black markings; eyes red; 250 long including rostrum; 100 wide; rostrum 35 long reaching nearly the middle of femur I; palpus 3 segmented, first segment 2 long; second segment 6 long with a long seta at its distal region, measuring 15 long; third segment 2 long with a thick blunt spine 4 long at its tip.

Rostral shield acutely bifurcate, reaching just the base of femur I; propodosoma clear except for a pair of long wavy lines in the middle and a pair of short lines on the sides; three pairs of dorsal propodosomal setae: DP I, 9 long; DP II, 11 long; DP III, 7 long. Hysterosoma with few markings, otherwise clear; 3 pairs of dorsocentrals DH I, 5 long; DH II, 4 long; DH III, 5 long, one pair of humerals, 5 long; five pairs of dorso-laterals, DLH I, 4 long, DLH II, 6 long, DLH III, 6 long; DLH IV, flagellate with minute spines, 190 long; DLH V, 4 long;

all setae on dorsum are narrow and lanceolate.

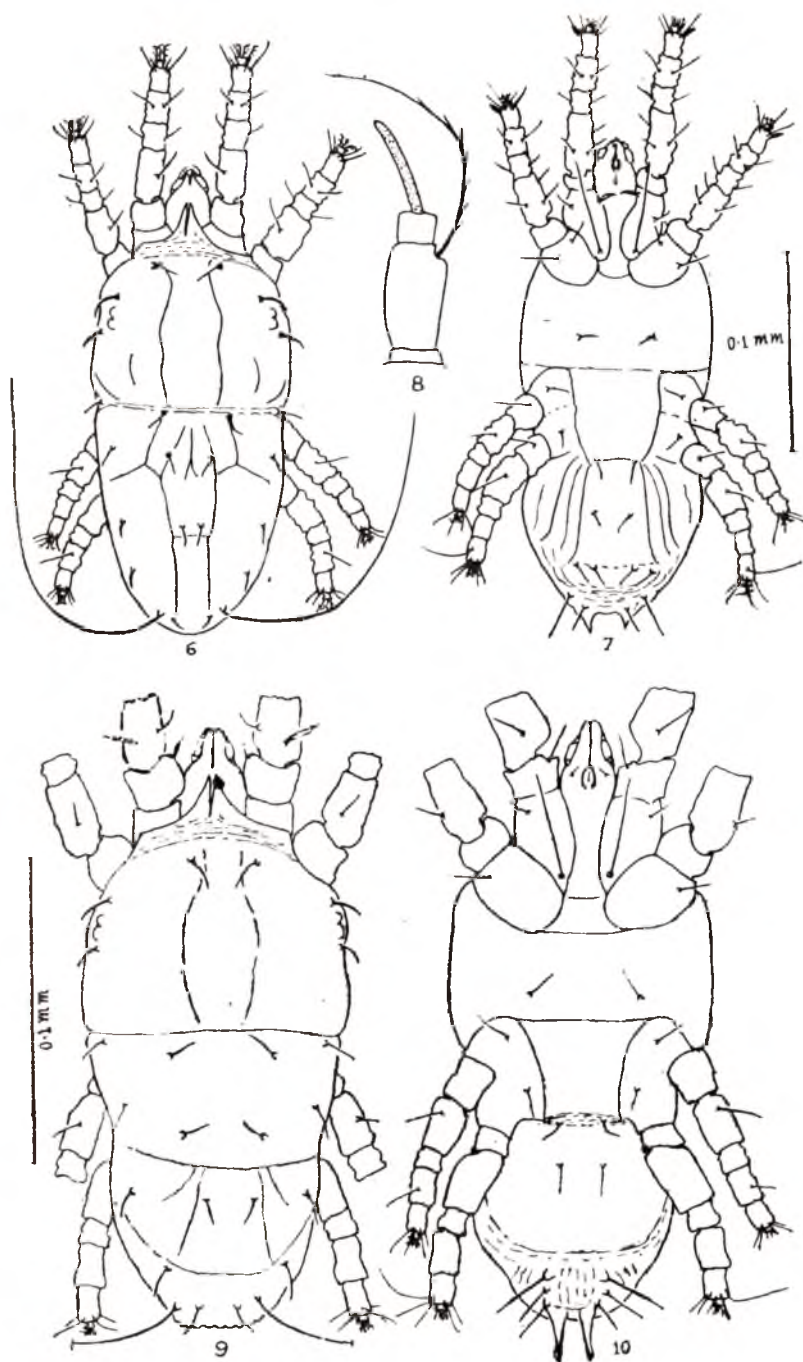
Venter with two pairs of medioventral propodosomals; anterior medioventral propodosomals 50 long near the forecoxal base; the posterior medioventral propodosomals 10 long near centre of the body; one pair of medioventral posterior metapodosomals 10 long; one pair of pregenital setae 8 long; two pairs of genital setae each about 10 long; and two pairs of anal setae, inner pair about 8 long, outer pair about 15 long; all setae on venter simple.

Setae on legs I to IV: coxae, 2,2,1,1; trochanter, 0,0,1,1; femora, 4,4,2,1; genua, 2,2,0,0; tibiae, 4,4,3,3; tarsi, 6(1), 6(1), 5,5. All setae simple except one pair on the forecoxae which is lanceolate.

Male: Very common, dirty white with black markings, eyes red, body 200 long, 90 wide; propodosoma with a pair of wavy longitudinal markings; metapodosoma, with a few longitudinal lines; dorsal setation similar to female, male genitalia spine like; ventrally the genito-anal region with three pairs of long setae instead of 4 pairs as in females, gnathosoma with a pair of small setae on the ventral side.

Types: A **holotype** slide with two males and two females and six **paratype** slides each with two males and two females, INDIA: TAMIL NADU Vridhachalam, ex *Mallotus* sp. (Euphorbiaceae), 12.xi.1981, Coll. M. Mohanasundaram (No. 73) TNAU.

Remarks: The adults of this species are quite active in their movements: the eggs are white, oblong without any ornamentation. This species is near *Tenuipalpus proteae* Meyer (1979) in its setal pattern of one pair of flagellate and 3 pairs of non-flagellate setae dorsocaudally



Figs. 6—10: *Tenuipalpus mallotae*, sp. nov. 6. Dorsal view of female; 7. Ventral view of female; 8. Palpus; 9. Dorsal view of male; 10. Ventral view of male.

and in the strong longitudinal striations; but could be differentiated from it by the white colour, smaller size and the leg setation.

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SEVEN NEW ERIOPHYID MITES (ERIOPHYOIDEA : ACARINA) FROM TAMILNADU

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The present paper gives the descriptions of seven new species of Eriophyids collected from Tamilnadu. They are : *Acalitus epiphytivrans*, sp. nov., *Artacris vadalorensis* sp. nov., *Aceria banyani* sp. nov., and; *Aceria leucophloeae* sp. nov. and under Eriophyinae: *Anthocoptes rutacevagrans*, sp. nov., *Epitrimerus morindae* sp. nov, under Phyllocoptinae of Eriophyidae and *Diptilomiopus thangaveli* sp. nov. under Diptilomiopinae of Rhyncaphytoidae.

(Key words: new eriophyid mites from India)

In the course of collection of Eriophyid mites from Tamilnadu, the following seven species, which are new to science, were collected and studied. They have been adequately sketched and described. The following abbreviations have been used in the figures of mites: API, Internal female apodeme, CS, Side view of caudal end; D, Dorsal view of mite; DA, Dorsal view of anterior section of shield; ES, Side skin structure; F, Feather claw; GPI, Female genitalia and coxae from below; LI, Left fore leg; S, Side view of mite.

The type slides have been deposited in the Department of Agricultural Entomology collections, Tamilnadu Agricultural University, Coimbatore, India.

1. *Acalitus epiphytivrans* sp. nov. (Fig. 1)

This species resembles *Acalitus hassani* Keifer (1973) in its shield design and 7 rayed feather claw but could be differentiated from it by the longer coxal setae: the crescentic scorings on the fe-

male genital cover flap; presence of accessory seta in the telosome; and the size of the body. *Acalitus hassani* Keifer is an erineum maker, deforming the leaves, while the present species is vagrant without causing any symptoms.

Female: Worm like, 270—280¹ long, 60 thick, rostrum 12 long, evenly down curved; antapical seta 3 long. Shield 40 wide, 30 long, with a clear pattern of lines. Median represented in the rear half of the shield, with cross lines joining the admedians; admedians curved and bifurcates in the anterior half; first submedian joined with the admedian in the rear one third and bifurcates in the anterior half; second submedian branched in the rear half and joins with the first submedian; third submedian forms the border of the shield; sides of the shield slightly granular; dorsal tubercles at rear shield margin, 22 apart; dorsal setae 17 long pointing backwards. Fore leg 30 long; femoral seta absent; tibia 5 long, tibial seta absent; tarsus 8 long; claw 9 long; feather claw 7 rayed. Hindleg 30 long; tibia 5 long; tarsus 8 long; claw

¹ All measurements are in μ m unless otherwise stated.

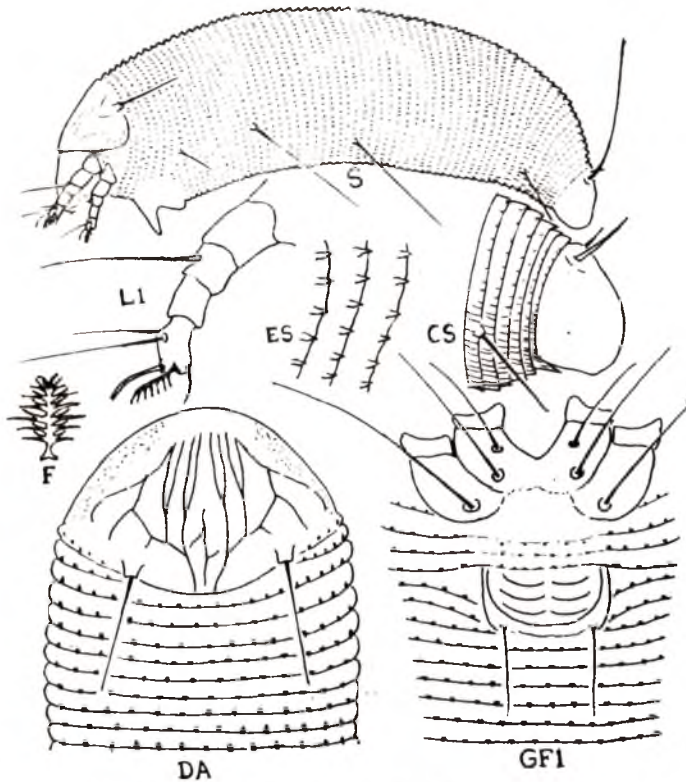


Fig. 1. *Acalitus epiphytiavagrans* sp. nov.

9 long. Coxae with all three setiferous tubercles, widely separated; coxal seta I, 25 long; seta II, 35 long; seta III, 50 long; seta I and II in line: coxal area smooth. Abdomen with about 65 uniformly microtuberculate rings; microtubercles oval to elongated along the posterior margin of each ring; lateral seta 20 long on ring 9; first ventral seta 50 long on ring 20; second ventral seta 55 long on ring 36; third ventral seta 22 long on ring 5 from behind; caudal seta 140 long; accessory seta 3 long, Female genitalia 20 wide; 13 long, cover flap with 3 to 4 pairs of crescentic scorings separated in the middle, genital seta 15 long.

Male: Not known.

Types: A **holotype** slide and five

paratype slides all with ♀♀, INDIA : TAMIL NADU, South Arcot District, Kilacheruvai, 4 km from Thittagudi, collected on 16.viii.1981, ex unidentified epiphytic parasitic plant. Coll : M. Mohanasundaram (No. 431) (TNAU). The mites are under surface leaf vagrants causing slight crinkling of leaves.

2. *Artacris vadalurensis* sp. nov. (Fig. 2)

This species differs from all other known species of *Artacris* (Keifer, 1970) by its long anterior shield lobe; the shield pattern, 7 rayed feather claw and the granular coxal arc.

Female: Worm like, 205—215 long; 35 thick, rostrum 18 long, evenly down curved; antapical seta 4 long; shield 28 wide, 25 long; median complete, branched

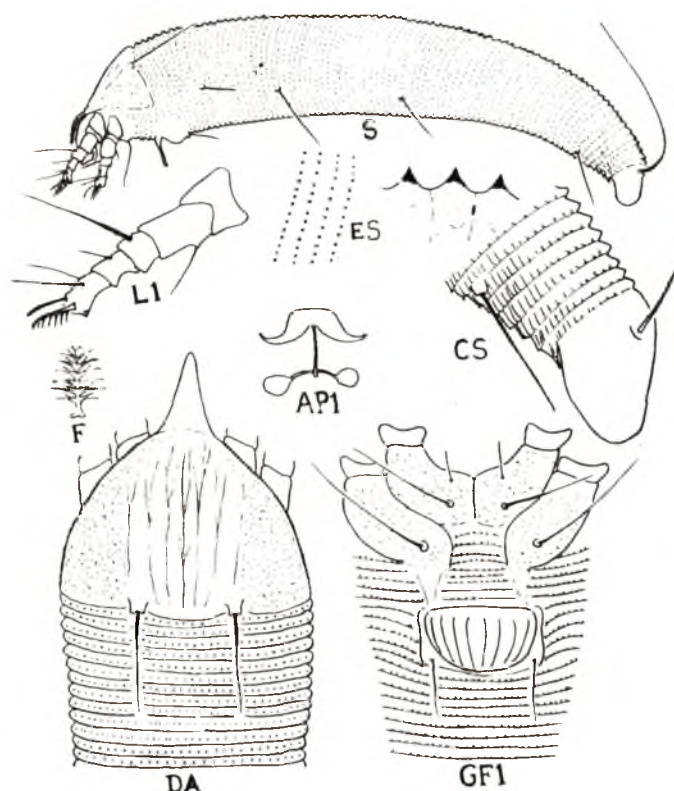


Fig. 2. *Artacris vadalorensis* sp. nov.

anteriorly; admedians, first and second submedians, all complete and branched anteriorly; sides of shield granular; anterior tip of shield with a narrow lobe about $\frac{1}{3}$ length of the shield over the rostrum; dorsal tubercles at rear shield margin, 12 apart; dorsal setae 30 long; pointing backwards; foreleg 25 long; tibia 4 long, tibial seta 3 long; tarsus 7 long; claw 5 long, curved; featherclaw 7 rayed; hind leg 23 long; tibia 4 long; tarsus 6 long; claw 9 long, straight; coxae with all three setiferous tubercles, coxal seta I short, in line with seta II, setae II and III long and prominent; with a clear sternal line, coxal area granular. Abdomen with about 80–85 rings, uniformly

microtuberculate, microtubercles dot like and placed closely, lateral seta 18 long on ring 12; first ventral seta 45 long on ring 22; second ventral seta 45 long on ring 45; third ventral seta 20 long on ring 8 from behind; caudal seta 65 long; accessory seta absent. Female genitalia 18 wide; 12 long; cover flap with about 8 lines; genital seta 10 long.

Male: Not known.

Types: A **type** slide and two **paratype** slides all with ♀♀, INDIA: TAMIL NADU: South Arcot District, Vadalur, 5. viii, 1981, ex unidentified thorny hedge plant (Leguminosae) Coll. M. Mohanasundaram (No. 419) (TNAU). The mites are under surface leaf vagrants.

3. *Aceria banyani* sp. nov, (Fig. 3)

This species resembles *Aceria infectoriae* Channabasavanna (1966) by its general pattern of shield lines but could be differentiated from it by the 6 rayed feather claw. It is also differentiated from *Aceria fici* (Essig) (Keifer, 1938), by the 6 rayed feather claw and the difference in the shield pattern apart from the measurements, even though it resembles by its granular coxal area, and sides of shield.

Female: Worm like, white; 200-210 long; 40 thick, rostrum 18 long, evenly down curved; antapical seta 4 long; shield 28 wide; 23 long with a clear pattern; median and admedians complete; first submedian complete, bent in the middle;

second and third submedians short and curved; fourth submedian forms the border of the shield, branching posteriorly; sides of the shield granular; dorsal tubercles at the rear shield margin, 15 apart; dorsal setae 22 long, pointing backwards; foreleg 25 long; tibia 5 long; tibial seta, 4 long at basal 1/3; tarsus 6 long; claw; 7 long; feather claw 6 rayed; hind leg 20 long; tibia 4 long, tarsus 5 long, claw 9 long; coxae widely joined; with all three setiferous tubercles coxal setae I and II in line; seta I, 15 long; seta II, 35 long; seta III 45 long; fore coxae completely granular; hind coxae granular around the setiferous tubercles. Abdomen with about 70 uniformly microtuberculate rings, microtubercles elongated along the posterior margin of each ring; lateral seta

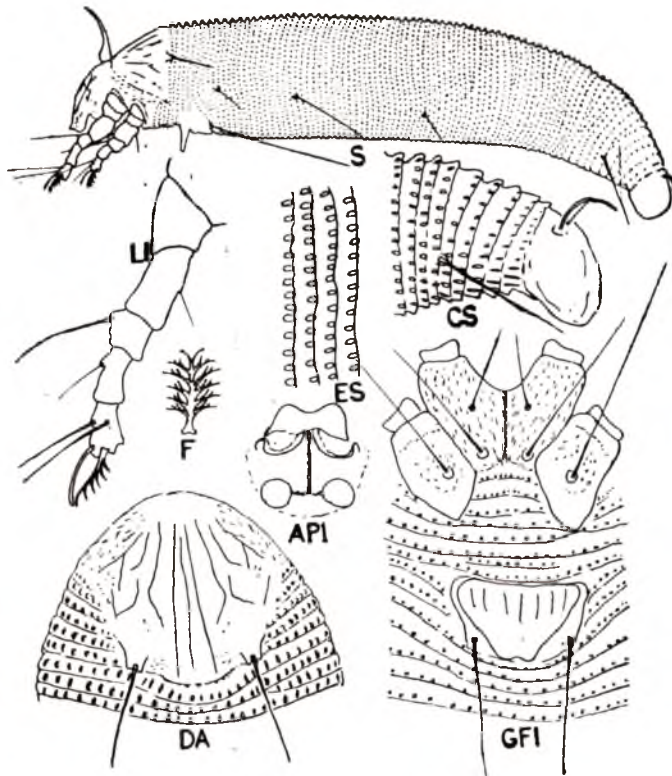


Fig. 3. *Aceria banyani* sp. nov.

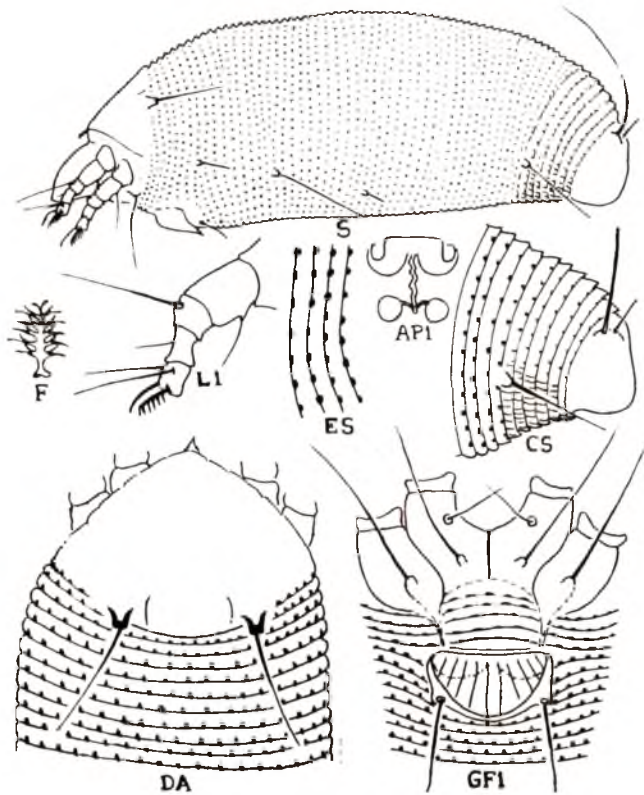


Fig. 4. *Aceria leucophloeae* sp. nov.

12 long on ring 10; first ventral seta 55 long on ring 22; second ventral seta 12 long on ring 44; third ventral seta 27 long on ring 6 from behind; caudal seta 50 long; accessory seta 3 long. Female genitalia 15 wide, 10 long; coverflap with 6—8 lines; genital seta 45 long.

Male: Not known.

Types: A **holotype** slide and five **paratype** slides all with ♀♀, INDIA: TAMIL NADU, Vridhachalam 8.v.1981 ex, *Ficus bengalensis*. L (Moraceae), Coll. M. Mohanasundaram (No. 411) (TNAU). The mites found on tender shoot.

4. *Aceria leucophloeae* sp. nov. (Fig. 4)

This species resembles *Aceria distichli* (Keifer 1961) in its shield pattern, but

could be differentiated from it by the 6 rayed feather claw, larger number of lines on the female genital cover flap; shorter lateral and second ventral setae; and smaller body measurements. Moreover *A. distichli* Keifer is a grass infesting sheath mite, while the present species is an undersurface leaf vagrant on a dicotyledonous host.

Female: Light brown, worm like, 145–150 long; 50 thick; rostrum 15 long, evenly down curved. antapical seta 6 long; shield 35 wide, 25 long; shield area and sides of shield clear except for the short representation of the admedians near the rear margin of the shield; dorsal tubercles at shield margin, 15 apart; dorsal setae 20

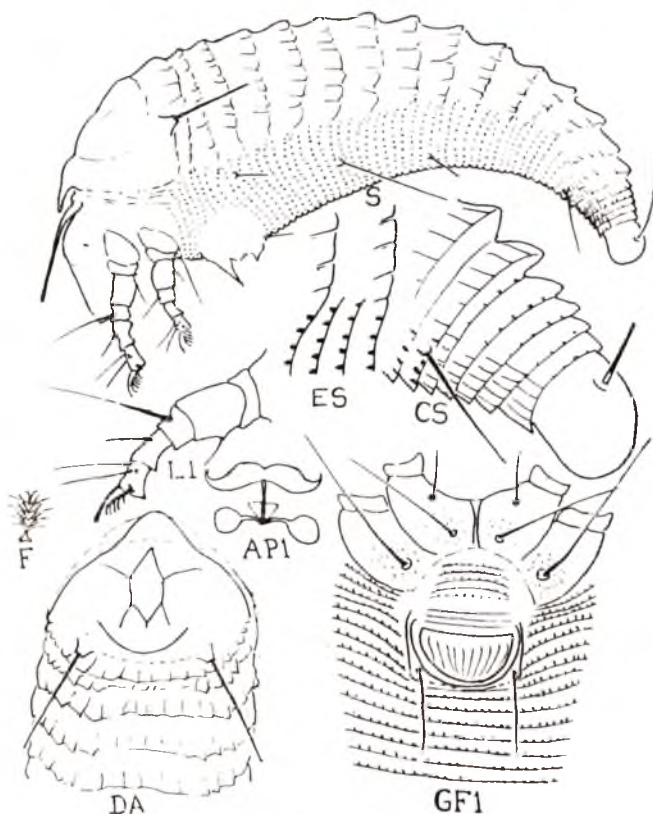


Fig. 5. *Anthocoptes rutaacevagrans* sp. nov.

long, pointing backwards and outwards; fore leg 23 long; tibia 6 long; tibial seta 4 long; tarsus 5 long; claw 8 long; feather claw 6 rayed; hind leg 23 long; tibia 6 long; tarsus 5 long; claw 8 long; coxae with a clear sternal line, all three setiferous tubercles present; coxal setae long and prominent; coxal seta I placed wider apart than seta II; seta III on prominent base; coxal area smooth, abdomen with about 52 rings uniformly microtuberculate; microtubercles along the posterior margin of each rings; lateral seta 15 long on ring 12; first ventral seta 52 long on ring 21; second ventral seta 11 long on ring 31; third ventral seta 20 long on ring 5 from behind; caudal seta 95 long; acces-

sory seta 8 long; female genitalia 17 wide; 10 long; coverflap with 10—12 lines; genital seta 20 long.

Male: 140—145 long; 50 thick; genitalia 15 wide; genital seta 14 long.

Types: A **holotype** slide with ♀♀ and 5 **paratype** slides with ♀♀ and ♂♂, INDIA: TAMIL NADU, South Arcott District Pennadam, 5.viii.1981, ex *Acacia leucophloea* L. (Leguminosae) Coll. M. Mohanasundaram (No. 418) (TNAU).

Remarks: The mites cause characteristic leaflet base galls, wherein the bases of the opposite leaflets join to form a gall [cavity inside which all the stages of the mites are seen. The galled area of

the leaflets is pinkish brown while the rest of the lamina is green.

5. *Anthocoptes rutacevagrans*, sp. nov. (Fig. 5)

The present species differs from all other *Anthocoptes* in its shield design, number of tergites and measurements. The nearest species is *Anthocoptes gutierreziae* Keifer (1962) but the new species differs from it by its 5 rayed feather claw, larger number of tergites and the shield markings.

Female: Light brown, 145—155 long, 45 thick, rostrum 18 long, down curved, antapical seta 4 long; shield 38 wide, 30 long with an anterior lobe over rostrum base; median absent; admedians and submedians forming an elongate hexagonal cell in the middle of the shield; dorsal tubercles at shield margin, 20 apart; dorsal setae 20 long, quite thick; foreleg 25 long; tibia 7 long; tibial seta 4 long; tarsus 6 long; claw 6 long, curved; feather claw 5 rayed, thin; hind leg 22 long; tibia 6 long; tarsus 6 long; claw 6 long, curved; coxae widely separated, with all three setiferous tubercles; coxal seta I and III placed wider apart than coxal seta II; coxal area lightly granular. Abdomen with about 20 broad tergites with faint elongate microtuberculation; 45 sternites with thick microtubercles; lateral seta 16 long on ring 8; first ventral seta 35 long on ring 18; second ventral seta 8 long on ring 26; third ventral seta 15 long on ring 5 from behind; caudal seta 35 long; accessory seta dot like; female genitalia 20 wide, 12 long; cover flap with 10—12 lines; genital seta 20 long.

Male: Not known

Types: A **holotype** slide and six **paratype** slides, all with ♀♀. INDIA:

TAMIL NADU, South Arcot District, Kilacheruvai 4 km from Tittagudi, 16.viii.1981, ex *Murraya exotica*, L. (Rutaceae) Coll. M. Mohanasundaram (No. 430) (TNAU). The mites are found on the tender shoots among the brown pubescence.

6. *Epitrimerus morindae*, sp. nov. (Fig. 6)

The present species resembles *Epitrimerus chandramohani* M. Mohanasundaram (1980) but could be differentiated from it by the 4 rayed feather claw; female genital coverflap with 6—8 faint lines without the basal granulations; smooth coxal area; and granular anterior border of the shield apart from the larger size.

Female: Dorsoventrally flattened, spindle shaped, yellowish brown in colour, 200—210 long; 75 wide, rostrum 12 long, down curved; antapical seta 5 long; shield 75 wide, 50 long; median broken and very faint; admedians broken but complete; first submedian faint and broken, represented in the anterior half of the shield; a second submedian forming the curved border in the anterior portion enclosing a granular area anteriorly; dorsal tubercles, just away from rear shield margin, longitudinally elongated, 20 apart; dorsal seta 3 long pointing upward and inward. Foreleg 32 long; tibia 7 long; tibial seta 5 long; tarsus 6 long; claw 5 long, knobbed at tip; feather claw 4 rayed appearing divided in dorsal view; hind leg 28 long; tibia 6 long; tarsus 6 long; claw 5 long, knobbed at tip; coxae widely separated, all three setiferous tubercles present; third coxal setae thick and long; coxal area clear. Abdomen with about 30 broad tergites with faint elongated microtubercles; about 65 sternites with thick microtubercles on the sides and smaller microtubercles in the middle; lateral seta 25 long on ring 10; first ventral seta 55 long

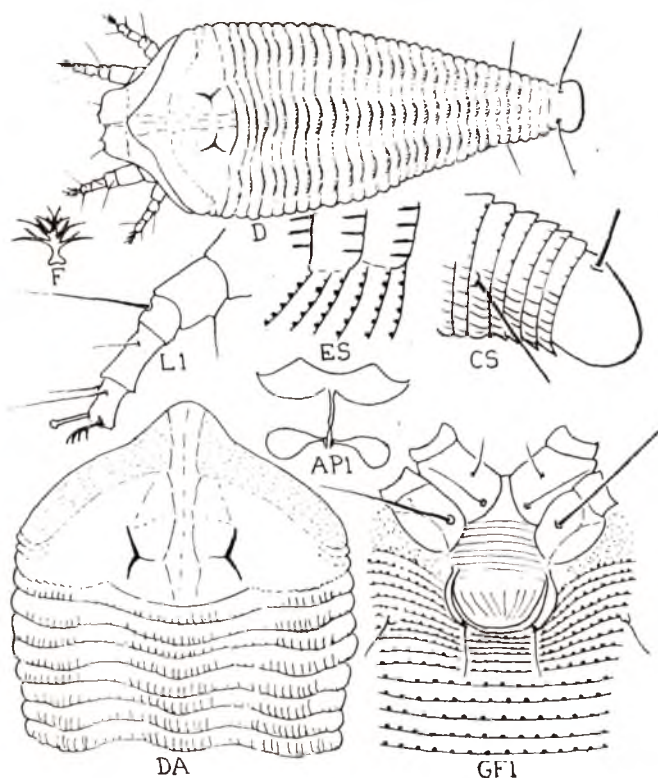


Fig. 6. *Epitrimerus morindae* sp. nov.

on ring 22; second ventral seta 8 long on ring 38; third ventral seta 25 long on ring 5 from behind; caudal seta 42 long; accessory seta absent; female genitalia 25 wide; 15 long coverflap with about 6—8 faint lines; genital seta 10 long.

Male: Not known.

Types: A **holotype** slide and two **paratype** slides all with ♀♀. INDIA: TAMIL NADU, South Arcot District, Kilacheruvai, 4 km from Tittagudi, 16.viii.1981, ex. *Morinda tinctoria* (Rubiaceae) Coll. Mohanasundaram (No. 423) (TNAU). The mites are undersurface leaf vagrants.

7. *Diptilomiopus thangaveli*, sp. nov. (Fig. 7)

This species is differentiated from *Diptilomiopus abronius* (1939) by the

absence of the foretibial setae, clear coxal area and lesser number of rays in the divided feather claw; from *D. assamica* Keifer (1959) by the shield pattern, granular genital coverflap and clear coxal area; from *D. carolinensis* Keifer (1940) by the shield pattern and feather claw; from *D. davisii* Keifer (1969) by the presence of patellar segment in the legs from *D. jevremovici* Keifer (1960) by the shield pattern and clear coxal area and from *D. camerae* Mohanasundaram (1981) by the 5 rayed feather claw; non granular coxal area, genital coverflap with crescentic scorings and the equal length of the first and second ventral setae.

Female: Yellowish brown, spindle shaped, 180—200 long, 70 thick; rostrum

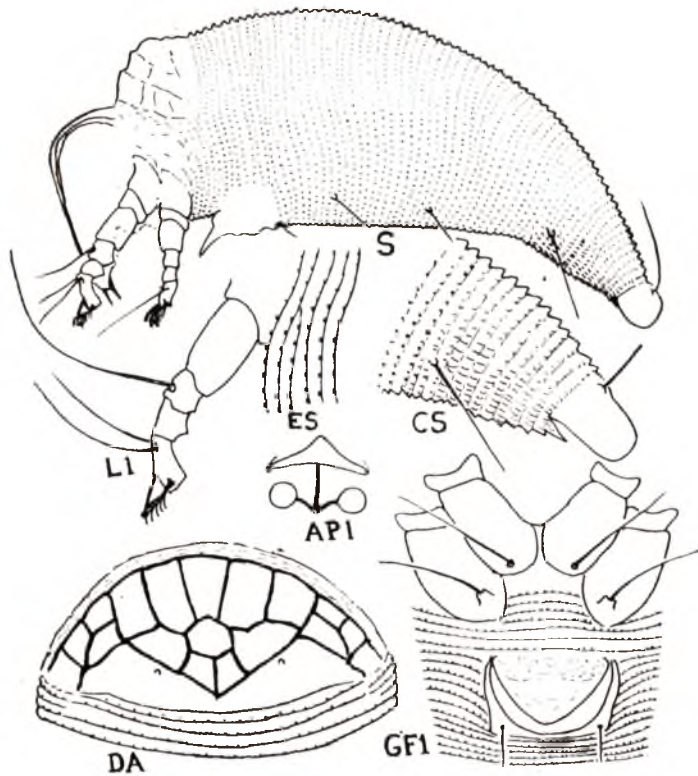


Fig. 7. *Diptilomiopus thangaveli* sp. nov.

30 long, abruptly down curved with long form oral stylets; shield 50 wide; 25 long with a clear pattern of thick lines forming a network of cells; one row of cells bordering the anterior end numbering 11, followed by 7 cells behind; dorsal tubercles away from rear shield margin, 20 apart; dorsal setae absent. Fore leg 35 long tibia 5 long, tibial seta absent, tarsus 10 long; claw 7 long with knobbed tip; feather claw divided with 5 rays in each; hind leg 30 long, tibia 3 long; tarsus 8 long, claw 7 long with knobbed tip; coxae widely separated, first setiferous coxal tubercles absent; coxal setae II and III nearly of equal length; coxal area smooth. Abdomen with about 55 tergites finely microtuberculate; about

80 sternites with thicker microtubercles lateral seta absent; first ventral seta 7 long on ring 30, second ventral setae 7 long on ring 48; third ventral seta 35 long on ring 10 from behind; caudal seta 70 long; accessory seta dot like; female genitalia 25 wide, 16 long, just away from coxal base; cover flap with basal granulations and distally with short cross lines; genital seta 6 long.

Male: Not know

Types: A **holotype** slide and six **paratype** slides, all with ♀♀, INDIA: TAMIL NADU, Chidambaram, ex. *Casearsa toneritosa* Roxb. (Flacourtiaceae) 5.viii. 1981; Coll. M. Mohanasundaram (No.220) (TNAU). The mites are under surface

leaf vagrants without causing any symptoms,

The mite has been named after Dr. S. Thangavelu my colleague who helped me in the collection of this species.

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A NEW GENUS AND SPECIES OF MESOSTENINAE (HYMENOPTERA : ICHNEUMONIDAE) FROM INDIA

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A new genus and species of Mesosteninae (Ichneumonidae), *Neobuodias indicus*, collected from Maharashtra, India, is described. The relationships of the genus are discussed.

(Key words: *Neobuodias indicus*, gen. nov., sp. nov. from India)

The Mesosteninae is a moderately large subfamily of Ichneumonidae. Most of the species are endophagous parasitoids of lepidopterous pupae. The genera of Mesosteninae have been studied and redefined recently (Townes, 1961, 1969 b; Jonathan and Gupta, 1973). Amongst the material collected from Maharashtra, is an undescribed species which could not be placed in any of the known genera using either of the above works. This genus is described here and compared with the related taxa. The terminology used follows Townes (1969 a). The drawings were made using camera lucida.

***Neobuodias*, gen. nov.**

Type species *Neobuodias indicus*, sp. nov. The name is derived from the known genus, *Buodias*.

Frons (Fig. 5) with median vertical elevated carina. Clypeus slightly apically truncate, without any tooth. Mandibles equidentate. Lateral part of the pronotal collar with a narrow, flat front edge bordered by a carina. Epomia strong, distinct, apically divergent. Sternaulus reaching mid coxa, its posterior 0.4 distinct. Lateral carinae of scutellum (Fig. 3) basally strong, apically weak. Basal carina of propodeum complete: apical

carina (Fig. 8) present throughout, convex medially: propodeal spiracle oval, 2 times as long as broad. Apical lobes of fourth segment of tarsi nearly of equal length. Areolet (Fig. 1) 0.6 times as high as the portion of the second recurrent vein above bulla. Second recurrent vein reclivous. Mediella (Fig. 2) slightly convex. First tergite with lateral triangular basal teeth, with complete dorso-median carina, lateral carinae present only on postpetiole (Fig. 9); median part of post petiole (Fig. 4) with sparse deep punctae. Ovipositor (Fig. 7) long, slender, its dorsal profile convex, tip straight, upper side not flattened beyond nodus, its nodus is distinct; ovipositor sheath 2 times as long as its hind tibia.

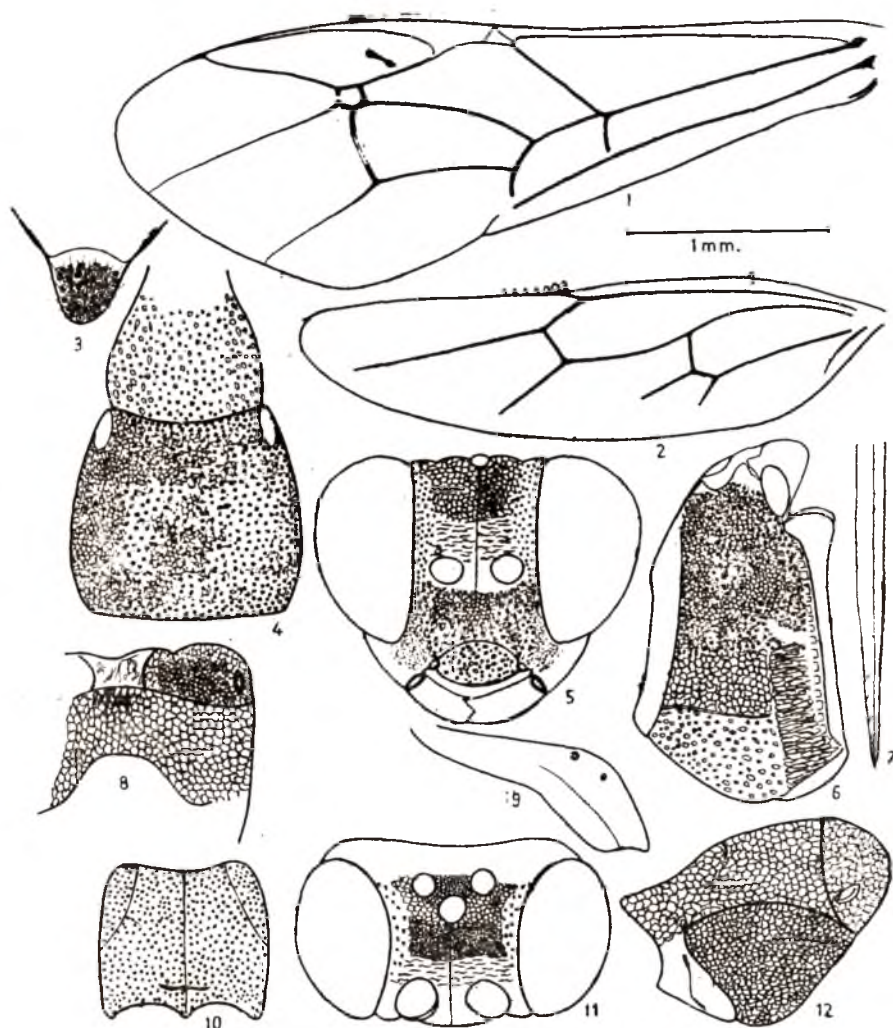
***Neobuodias indicus*, sp. nov.**

The name *indicus* is derived from the name of the country, India.

Female: 12.5 mm, face (Fig. 5) finely pubescent, moderately elevated, finely, closely punctate, apically slightly broader than at apex, 0.5 times as long as broad. Clypeus emarginate, finely sparsely punctate, medially convex, twice longer than its breadth. Mandibles striato-punctate, medially 0.7 times as broad as at base. Frons basally rugose, rest striate. Antenna

26 segmented, first flagellar segment slightly longer than scape and pedicel combined; basal and apical segments narrower than the broader middle segments. Malar space granulose, 2 times as long as basal width of mandibles. Vertex finely punctate. Ocelli (Fig. 11) in a

triangle, distance between median and basal ocelli one-third that of the same between the basal ocelli; ocello-ocular distance twice that of ocellar diameter. Genal carina almost touching the base of mandible, eyes emarginate.



Figs. 1—12: *Neobuodias indicus* gen. nov., sp. nov. 1. Fore wing; 2. Hind wing; 3. Scutellum; 4. Postpetiole and second abdominal tegite; 5. Head, front view; 6. Mesopleurum; 7. Tip of ovipositor; 8. Part of propodeum (dorsal view); 9. First abdominal segment (lateral view); 10. Mesosternum; 11. Head (dorsal view); 12. Metapleurum and part of propodeum.

Propodeum reticulate and punctate; Mesonotum sparsely, deeply punctate; notauli strong. Scutellum (Fig. 3) sparsely punctate. Mesopleurum (Fig. 6) sparsely, strongly punctate except for the striate basal corners; prepectal carina strong on basal half. Mesosternum (Fig. 10) distinctly sparsely punctate, with a median sternal groove. Metapleurum (Fig. 12) reticulate. Propodeum less than 1.0 as long as wide, portion behind basal carina punctate, rest of the area strongly rugose except for the short median longitudinal striations in front of the basal carina. Hind coxa 1.3 times as long as broad; trochanter 1.25 times as long as trochanterellus; tibia 1.25 times the length of femur; claws simple. Fore wing (Fig. 1) 3.8 mm in length and 1.3 mm in breadth; costa and first abscissa of radius of equal length; second discoidal cell nearly 3 times as long as broad; nervellus slightly proximal to basal vein. Hind wing (Fig. 2) with 1+7 hamuli; superior and inferior nervellar abscissae 14 : 10.

Abdomen depressed; first tergite slightly longer than second, spiracle circular, on apical third (Fig. 9), second (Fig. 4) and other tergites closely deeply punctate; ovipositor long, exerted, straight.

Dark brown. Face, frons, interocellar space, vertex blackish; antennae basally and apically blackish-brown and medially with whitish band. Abdomen apically and eyes black.

Male: Unknown.

Holotype : ♀ INDIA; MAHARASTRA, Aurangabad, Hymayatbagh, on wing, 28.vii.1973, Coll. R. S. Bandelu. **Paratypes** 3 ♀♀, 3.viii.1973, other data as holotype.

Distribution: India.

Remarks: *Neobuodias* resembles *Buodias* Cameron in the characteristics of first

abdominal tergite, scutellar carinae, propodeal basal transverse carina, its spiracle and the mandibular teeth. It runs close to this genus in the keys by Townes (1961, 1969 b). However, it differs from the same in having; epomia distinct and apically divergent; sternaulus reaching the mid coxa, its posterior 0.4 distinct; apical carina of propodeum present throughout; areolet 0.6 times as high as the portion of second recurrent vein above the bulla and ovipositor tip straight, dorsally not flattened beyond nodus. *Neobuodias* possesses some peculiarities of the genera of **Goryphus* Holmgren in having ovipositor tip long, slender and its dorsal profile not flattened. In view of these differences this species could not satisfactorily be assigned to any of the known taxon but clearly represents a new genus. *Neobuodias* gen. nov. may be included in the key to genera by Townes (1969 b) as follows:

***Goryphus** Complex (Jonathan & Gupta, 1973). It differs from the 21

Arolet about 1.0 as high as the portion of second recurrent vein that is above bulla. Upper side of ovipositor flattened beyond nodus, the ovipositor tip often decurved. Frons sometimes with a median vertical compressed tubercle or low crest. Ethiopian and Oriental regions . . . *Buodias* Cameron

Arolet 0.6 as high as the portion of second recurrent vein that is above bulla. Upper side of ovipositor tip straight. Frons with a median vertical elevated carina. Oriental region
 *Neobuodias*, gen. nov.

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BIONOMICS OF *TRIOXYS* (*BINODOXYS*) *INDICUS*, AN APHIDIID PARASITOID OF *APHIS CRACCIVORA*. 16. THE COMPETENCY OF THE FEMALE PARASITOID TO FERTILISE THE EGGS FOLLOWING INSEMINATION

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The present investigations confirm that the functional virginity of *Trioxys indicus* is less than 5 minutes. However, longer pre-oviposition period following insemination significantly enhances the proportion of fertilised eggs, which is an adaptation of a potent bioagent. The production of male offspring by mated female, *i. e.*, the inhibition of fertilisation, as a by-product inherent in the physiology of the reproductive system is also supported by this work.

(Key words: Bionomics, *Trioxys* (*Binodoxys*) *indicus*, aphidiid parasitoid, competency, parasitoid)

The parasitoid, *Trioxys* (*Binodoxys*) *indicus* SUBBA RAO & SHARMA (Hym.: Aphidiidae) is an arrhenotokous and synovigenic species and the sex of the eggs is determined and differentiated by several extrinsic and intrinsic factors (SINHA & SINGH, 1979; PANDEY *et al.* 1982). In addition, the functional virginity of the female parasitoid following insemination has also been attributed to influence the sex determination of the eggs (MACKAUER, 1976; VAN DEN ASSEM & FEUTH-DE BRUIJN, 1977). The sex ratio of the parasitoid is an important issue in the biocontrol programme of the insect pest management with particular reference to aphids because the aphidiid parasitoids begin to oviposit just after emergence or copulation (SINGH & SINHA, 1980; PANDEY *et al.*, 1982). Hence it becomes necessary to know the time lapse when functional virginity (MACKAUER, 1976) of the inseminated female

ends for procuring a considerable number of females in the mass-culture of the parasitoid for the release practices. The present investigations were undertaken to ascertain the pre-oviposition period needed to yield female biased progeny for the introduction of *T. indicus* against the pigeon pea aphid, *Aphis craccivora* Koch (Hem.: Aphididae).

MATERIALS AND METHODS

The parasitoid, *T. indicus*, and the host, *A. craccivora* were reared in the laboratory at $18 \pm 2^\circ\text{C}$ and $75 \pm 5\%$ RH (SINHA & SINGH, 1980). Seven virgin females freshly emerged and fully fed along with seven male parasitoids were put in seven different tubes (10×1 cm) a pair in each and were allowed to mate. The mated females were then transferred separately into other glass vials (5×1 cm). Quickly, in the first vial one third instar nymph of the host was introduced (kept on a tender leaf of the host plant, *Cajanus* [cajan Millsp.] which was withdrawn after parasitoidisation. This process was repeated and continued up to the parasitoidisation of 25 nymphs. Similarly, in

2nd to 7th vials, same number of the hosts were introduced in identical manner after 15, 30, 60, 120, 240 and 360 minutes following insemination respectively. All the above sets were replicated 4 times. Each of the hosts after parasitoidisation were reared separately on the cuttings of the host plant with cut ends dipped in water-filled numbered bottles (1–25). The parasitoidised aphids when mummified were put on the fresh leaf of the host plant (for providing moisture to the developing parasitoids) and were placed in marked tubes. The egressed parasitoids out of the mummies were recorded and sexed.

OBSERVATIONS

T. indicus lays fertilised eggs even just after mating (*ca.* 5 minutes handling time) but the proportion of such eggs increases significantly only after 15 minutes following insemination. Therefore the functional virginity of *T. indicus* is for a very short time which is not in conformity with MACKAUER (1976) and VAN DEN ASSEM & FEUTH-DE BRUIJN (1977). According to them the fertilisation is unlikely to occur shortly after insemination. This physiological adaptation of *T. indicus* is very helpful in maintaining a female biased progeny in the field population - a desirable attribute of a bioagent (SINGH & SINHA, 1980). The proportion of the fertilised eggs laid by the female after 30 minutes of copulation increases steeply and thereafter, slowly with a tendency for stabilisation. A significant correlation ($r = 0.94$) exists between the proportion of fertilised eggs oviposited and pre-oviposition period (Fig. 1).

The probability of the fertilisation of the eggs oviposited by the female in a sequence of hosts (25 hosts in a succession) is uneven. The central tendency of observations made, shows that the probability of the fertilisation of alternating eggs is high (Fig. 2).

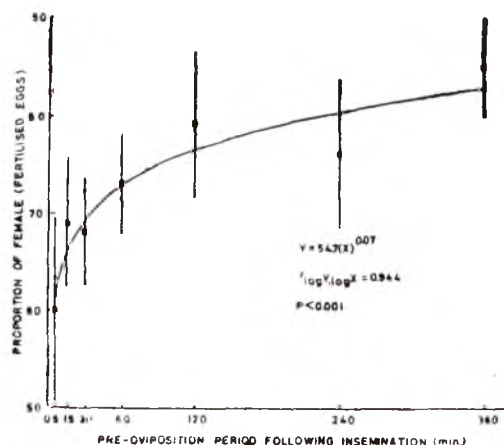


Fig. 1. Proportion of fertilised eggs (a ratio between female : female + male), at different pre-oviposition period following insemination, oviposited by *Trioxys indicus*.

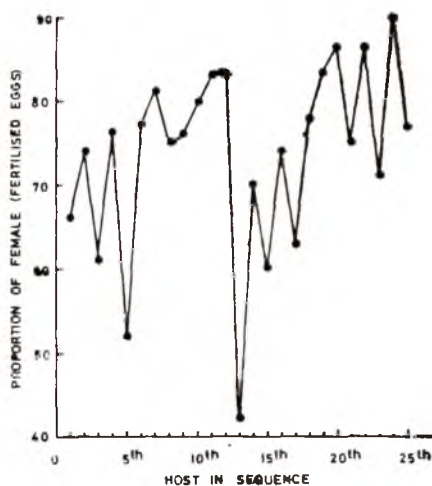


Fig. 2. Proportion of fertilised eggs (a ratio between female : female + male) oviposited by *Trioxys indicus* in a sequence.

DISCUSSION

Shortening of the pre-oviposition period of the parasitoid significantly decreases the proportion of fertilised eggs, possibly because of the non-availability of the activated sperms needed to

fertilise all the ovulated eggs. The in active sperms, stored in the spermatheca are activated by the fluid secreted by the spermathecal gland which is itself stimulated by several environmental factors (FLANDERS, 1946). The delay in oviposition (up to some extent) may cause secretion of the fluid in considerable quantity, thereby, activating more sperms that fertilise the same number of eggs.

The fate of fertilisation of the ovulated eggs in the mated female clearly shows that all the sperms do not simultaneously get activated, probably because of the fact that the diameter of the spermathecal gland duct is very narrow. Also due to the constricted nature spermathecal duct (SUBBA RAO & SAARMA, 1962) only one sperm can pass out at a time. Fig. (2) illustrates that at certain occasions more than one egg (mostly 2) pass down the oviduct at a time (one just following the other) so that the activated sperm coming from spermathecal duct fertilises only the first egg while the second egg passes down to ovipositor very quickly and remains unfertilised, and develops into a male parasitoid. These findings support the opinion of VAN DEN ASSEM (1977) that the inhibition of the fertilisation is a by-product inherent in the physiology of the reproductive system instead of a specific product of selection and not of MACKAUER (1976) as reported earlier (SINHA & SINGH, 1979).

The present investigation suggests that for mass-culture of *T. indicus*, freshly mated females may be utilised for procuring a female biased progeny as her functional virginity is for a very short period.

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BRIEF COMMUNICATION

ANALYSIS OF MOSQUITO COLLECTIONS IN THE DENGUE FEVER INFECTED LOCALITIES OF GURGAON URBAN, HARYANA STATE

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(Received 28 February 1983)

During the epidemic of dengue fever in Gurgaon urban, Haryana, an entomological study was made. All the mosquitoes belonging to *Aedes*, anopheline and culicine group were collected.

(Key words: Dengue fever, mosquito)

An epidemic of dengue fever occurred in Gurgaon between August and November 1982. No entomological observations were carried out before this outbreak incriminated *Aedes aegypti* as the primary vector of the disease. BANG *et al.* (1981) studied the seasonal variations in prevalence of *Aedes* mosquitoes breeding in peridomestic water containers in South-east Nigeria. Seasonal abundance of adult and immature *Aedes aegypti* was observed by NELSON *et al.* (1976). In the study reported herein, survey of adult populations were done in all the localities of Gurgaon urban. The Gurgaon city with a population of 111495 and total area 5.9 sq miles is situated 35 km from Delhi. The average annual rainfall was 69 mm. From August, 1982 until December, 1982 all the localities were surveyed at weekly intervals by one insect collector. The adult mosquito collections were carried out between 6.30 A M to 8.30 A M with an aspirator tube and flash light. Collections were made from fixed and random capturing stations (human dwellings, cattle sheds and mixed sheds)

from the peripheral and central zone of the city.

The number and species of mosquitoes taken from different type of collections are shown in Table I. Of 10679 mosquitoes collected from Aug. to Dec. in 1982, 0.14 per cent belonged to the *Aedes*. The apparent peaks of *Aedes* density was recorded in the month of October (16/man hour). *Anopheles subpictus* was the dominant species in cattle sheds (65.3 per man hour) in the month of August. Among culicine mosquitoes, *Culex fatigans* were recorded and having 49.1 density per man hour in cattle sheds in the month of November. The following discussion is restricted to the Northern region where *Aedes aegypti* is a vector of dengue haemorrhagic fever. In a study carried out by Virus Research Centre, Poona, in Vellore town the *Aedes* mosquitoes were found in the month of October and November. DEWAN CHAND *et al.* (1961) also observed the peak density of *Aedes aegypti* in the month of November and December in Gorakhpur

TABLE 1 Monthly mean number per man hour density of anopheline, culicine and *Aedes* mosquitoes.

Month (1982)	Rainfaall (mm)	Total man hour spent	Density per man hour		
			<i>Anopheles</i>	<i>Culex</i>	<i>Aedes</i>
August	270.5	28	41.5	40.8	Nil
September	5.8	42	35.7	33.2	Nil
October	1	46	14.6	29.5	14.7
November	2	36	8.2	33.4	16
December	7.5	56	2.6	31.1	Nil

(Uttar Pradesh). Experience with other mosquito borne diseases should have indicated that increased water availability is a premonitory sign that can lead to markedly increased population of the vector mosquitoes. During this study it was clear that highest density of *Aedes aegypti* recorded in the month of October and November and the dengue fever also appeared during the same time. In other contries in South east Asia several similar type of studies have directed towards relating the population density of *Aedes aegypti* to weather, season and incidence of dengue fever (SCANLON, 1966). In Singapore during 1966-1968 the density of adult *Aedes aegypti* in indoor resting collections generally fluctuated with rainfall (HO *et al.* 1971) and with dengue fever incidence (CHAN *et al.*, 1971 b).

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BRIEF COMMUNICATION

ON THE OCCURRENCE OF A NEW STEMBORER (*NUPSERHA VEXATOR* P.) AS A PEST OF *COLEUS*¹

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Nupserha vexator P. a cerambycid stemborer was observed as a pest in severe form on *Coleus parviflorus* (a tuber crop) at Trivandrum. The pest was prevalent during October-February. Nature and extent of damage and the life history of the pest are described.

(Key words: Cerambycid stemborer, *Nupserha vexator*, *Coleus*, tuber crop.)

Coleus parviflorus commonly known as *Koorka* or chinese potato, is the poor man's potato grown in the West Coast region of India for its edible tuber as a vegetable. During 1981-1982 a severe infestation of a stemborer on *Coleus* crop was observed in the Farm, CTCRI, Trivandrum. The pest was identified as *Nupserha vexator* Pascoe (Lamiinae : Cerambycidae : Coleoptera).

Earlier DUTT reported *N. bicolor* Th. (1915) and *N. bicolor postbrunnea* Dutt. (1964) as serious pests on soybean in Bihar and on *Oritoria*, jute crop in Bengal, Bihar, Orissa and UP respectively. *N. vexator* has been reported as a biological agent for the control of a weed (*Xanthium strumarium*) in Australia (WAPSHERE, 1974). From the review of literature it appears that this is the first record of *N. vexator* on *Coleus parviflorus*. An account of the nature and the extent of damage and the life history of the pest is presented in this communication.

Nature and extent of damage:

The adult beetles did not cause much damage to the crop. They often made

feeding scratches on the stem by biting and chewing. The grubs caused maximum damage by boring and tunnelling the stem to feed the xylem and pith areas (Fig. 1) and thus arresting the transmission of nutrients. Infested plants showed yellowing of leaves and drying of terminal buds with small fine frass coming out through the broken terminals and side cracks. This led to the initiation of small weak side shoots and the plants as a whole presented a sickly appearance resulting in poor yield from the crop. The grub cut more fibres than it could actually consume and the excess fibres were either packed in the tunnels or thrown outside through broken terminals and cracks of the stem as frass. The size of the fibres in the frass was fine and smaller during early stage of the grub and as they grew, the fibres were coarse and bigger. The grub also attacked the stem and thick roots underneath the soil.

As many as 6 to 9 grubs were recovered from a single plant of 3-4 months old. The field infestation was observed as 45 percent. The spread of the pest in the farm was due to usage of planting

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Fig. 1. Inset : adult *Nupserha vexator*; Main figure illustrates damage caused by the grubs to the stem of *Coleus*. Lower are the stages of the beetle.

materials procured from the infested fields which carried the eggs and early instars of the pest.

Life history: The eggs were laid on the tender stems, singly in the incisions made by the female beetle. The yellowish creamy egg was oblong measuring 2.8 to 4.0 mm in length and 0.8 to 1.0 mm in width. The incubation period was 4–5 days. The freshly hatched grub was 3.0 to 4.0 mm in length and was found feeding on the inner contents of the top shoots. The colour of the grub was yellowish cream and the full grown grub measured from 21 to 25 mm in length. The larval period ranged from 30 to 40 days. During studies in the laboratory up to four larval head capsules could be collected from the gallery, indicating more than five larval instars and this requires further studies. The larval moulting lasted for three hours. During moulting process first the head capsule was thrown aside and subsequently the body skin was removed by its wriggling movement. Usually after each moulting the grub fed on its own exuvium. Cannibalism was noted among the grubs. The matured grub prepared pupal chamber with coarse fibres and its oral secretions. The size of puparium ranged from 8.7 to 9.3 mm in length and 1.9 to 2.3 mm in width. Pupal chambers were usually found towards base of the stems or root region. The grub populated and emerged after 15 days through an exit hole.

The adult longicorn beetle is a small light brown long horned cerambycid measuring from 9.0 to 9.5 mm in length and 2.0 to 2.5 mm in width, with a conspicuous black patch at the post anal ends of the elytra (Fig. 1, inset). The length of antenna exceeded body length in male beetle whereas it was just the length of body in the female beetle. The posterior end of the abdomen ended abruptly with a concave shape in the male beetle, while the same was gradually converged and blunt in the case of female.

The total life cycle was completed within 49 to 60 days. Adult longevity ranged from 7 to 12 days. The pest was observed during the period from October to February. All stages of the pest (egg, grub, pupa and adult) could be recorded in the same plant, indicating the presence of overlapping generations.

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FINAL INSTAR NYMPH OF *UROTHEMIS SIGNATA SIGNATA* (RAMBUR) FROM SOUTH-WEST COAST OF INDIA

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Fully illustrated description of the final instar nymph of the Odonata *Urothemis signata signata* (Rambur) which has hitherto not been described, is presented on the basis of materials collected from a slow running canal, a brackish water lagoon and a freshwater pond in Trivandrum, Kerala, India.

(Key words: odonate nymph, *Urothemis signata signata*, predation, fish fry, mosquito larvae)

The material comprises 32 final instar nymphs collected from Chackai canal about 4 km west of Trivandrum city on 13th June 1978, 18 on 4th July 1978, 25 on 28th November 1978 from the Veli lake 7 km north of Trivandrum city and 6 from a pond in Vazhuthakadu in Trivandrum city on 14th December, 1978. The methods described by Nirmalakumari & Nair (1981) for *Rhodothemis rufa* (Rambur) was followed in the present study also.

***Urothemis signata signata* (Rambur) (Figs. 1—8)**

Libellula signata Rambur, 1842, *Ins. Nevrop*, p. 117.

Urothemis sanguinea Kirby, 1890, *Cat. Odon*, p. 23.

Urothemis signata signata Fraser, 1936, *Faun. Brit. Ind. Odonata*, Vol. III, p. 442.

Measurements:

Body length : 21 mm, head length : 4.5mm, width : 6.5 mm. thorax length : 5.5 mm, width 5 mm. abdomen length : width : 8mm, anal appendages : 2.5 mm. 8.5 mm, wing pads : 8 mm, antenna : 5 mm, legs : 12 mm, 15 mm, 21 mm.

Length of the body 21 mm (varying from 20—22 mm). Maximum width 8 mm across the 6th abdominal segment.

Colour generally straw yellow, pale brown or green rarely dark. Abdomen with dark spots on both the sides dorsally. Body fairly setose. Head broader than long. Eyes antero-lateral in position, trapezoidal with outer postero-lateral angles acute. Posterior margin convex bearing small, thick bristles. Mask reaching upto the base of the mid-coxae ventrally and is large covering the face nearly to the base of the antennae. Antenna seven-segmented, filiform, longer than the distance between the base of the antennae; without setae (Fig. 2). Third segment longer than all the other segments and is equal to any of the two segments taken together except the 4th and 5th combined.

Labium almost triangular in shape (Fig. 3). Median lobe of the prementum conical, slightly crenulated with small claviform setae at the anterior margin (Fig. 4). Premental setae 12+12. Lateral margins of the prementum smooth. The anteriormost pair of the lateral margin



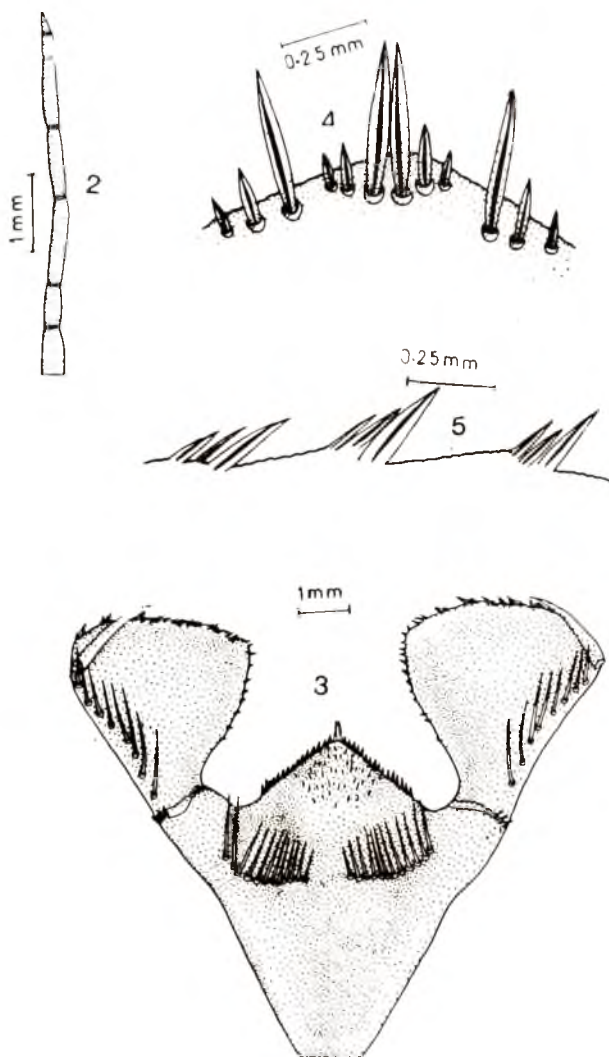
Figs. 1—8, *Urothemis signata signata* (Rambur): 1. Larva.

of the prementum just below the insertion of the palpus bear three spiniform setae. Small setae are present at the anterior portion of the median lobe. Distal margin of the palpus with crenations each bearing three to four setae (Fig. 5). Inner margin of the palpus bear small spine-like setae while the outer margin smooth. Palpal setae 8 & 8. Movable hook, medium sized. Mandible semitriangular (Fig. 6).

Thorax longer and narrower than head. Dorsal side bears two brown patches. Legs are hairy, stiff and spreading.

All femora marked with brown bands but the bands on the forefemora prominent. Tibial comb bears a number of simple, long spines and setae (Fig. 7). Three segmented tarsi bearing claws are beset with a double row a simple setae.

Abdomen elongated, oval in shape, flattened ventrally and triangular in cross sections. Brown patches are present all over the abdomen. Mid-dorsal hooks are present on segments 4—8, progressively larger. Posterior ones are larger while the anterior ones are shorter and are directed posteriorwards. Paired



2. antenna; 3. labium; 4. enlarged view of the mid anterior margin of the prementum; 5. enlarged view of the distal margin of palpus.

dorsal puncta present on segments 8 and 9. Large lateral spines are present on segments 8 and 9. Ninth lateral spine is twice the length of the 8th one. Lateral margins of the 8th and 9th segments bear small spinules and hairs. Wing pads lie close to the lateral sides of the abdomen and reach up to the 7th abdominal segment anteriorly.

Anal appendages are longer than the combined length of 9th and 10th segments taken together (Fig. 8). Epiproct is triangular in shape. Paraprocts are semitriangular, and larger than the epiproct. Both bear spinules and hairs on the lateral sides. Cerci half the length of the epiproct and less than half the length of the paraprocts. Lateral spine

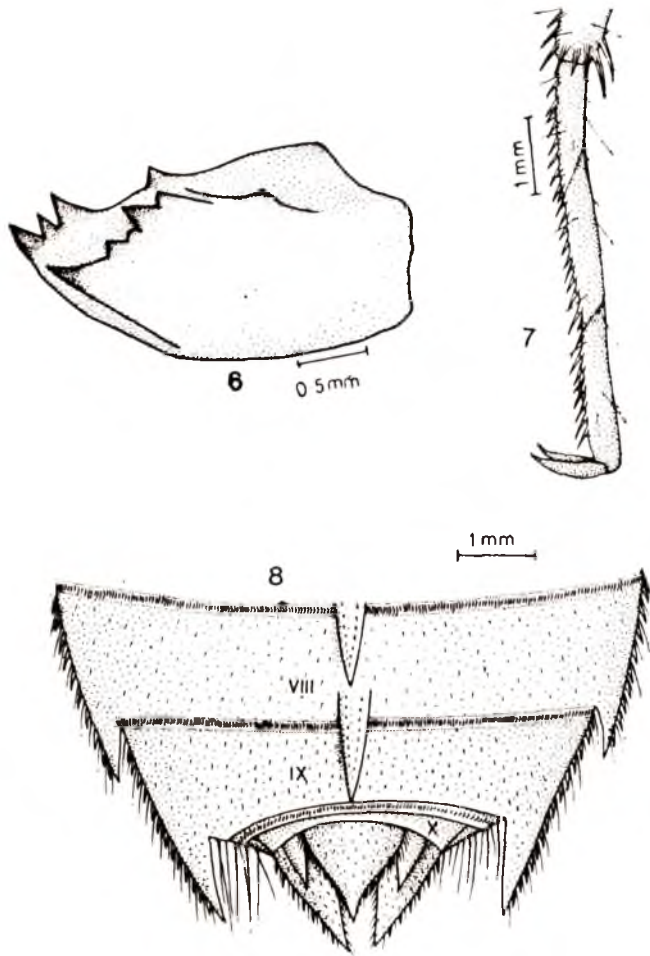


Fig. 6. mandible; 7. tibial comb and tarsi; 8. anal appendages.

of the 9th segment reaches upto $\frac{3}{4}$ length of the paraprocts and equal to the length of the epiproct.

Biological note: This is a common species occurring in the southern part of Kerala. The nymphs are straw yellow, greenish or dark brown in colour and are abundantly seen in ponds, slow running streams etc. Full grown nymphs were collected during the months of June—July and November—December. They are active swimmers and usually remain confined

to the bottom or cling on to the water weeds. At the slightest disturbance they dart rapidly through water, pumping jets of water through the anus. In the laboratory they thrive well on mosquito larvae, tadpoles, fish fry and other small animals and are highly predaceous: within a period of 24 hours a nymph was seen to consume an average of 14 small fish fry. They showed cannibalistic tendencies when there was shortage of food.

Distribution: Burma, Ceylon, India nov.

Remarks: Snehalatha (1954) collected this nymph from Kerala for the first time and has presented a very brief description. Since the previous description is inadequate, detailed descriptions with relevant diagrams are given in the present investigation. The earlier description does not mention about the setae present on the tibiotarsi, on the anterior region of the presence of three spiniform setae at the base of the palpus and of the anal appendages. Her collections included only nymphs which were straw-yellow in colour while in the present collection dark brown and green coloured nymphs were also obtained. Snehalatha's material was from a perennial tank but the nymphs for the present study were collected from differ-

ent types of habitats such as pond, slow running stream and a brackish water lake.

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OBITUARY



Dr. M. G. Jotwani

Dr. M. G. Jotwani—an eminent entomologist of international repute—left for his heavenly abode on Saturday the 4th June 1983.

Mulchand Girdharlal Jotwani was born on 31st May 1926 at Sehwan—a small town in Sind (Pakistan). He had his earlier education at Karachi and graduated in 1947 from the University of Bombay. Unfortunately, due to the partition of the country he could not continue his education at Karachi and migrated to India. He got his Assoc. IARI in 1950 and obtained his Ph. D. in 1965.

Dr. Jotwani started his career at Central College of Agriculture, New Delhi in October 1950. He joined the Directorate of Plant Protection, Quarantine & Storgae, Government of India in May 1951 as Locust Warning Officer. In February 1953 he returned to his alma mater, IARI, New Delhi where he worked till the end. With his sincere and honest work, he went on rising step by step under the able stewardship of Dr. S. Pradhan. He was Assistant Entomologist

(insecticide testing) till 1962 and Entomologist (seed testing) from 1962 to 1965. He became Senior Entomologist and Technical Project Leader of all-India co-ordinated projects on sorghum and millets in 1965. In addition he was the Head, Division of Entomology, IARI from 1-12-1978 to 31-12-1979. He was also on FAO panel of experts of rainfed crops.

Dr. Jotwani was one of the foremost insect toxicologists of India. He developed standard biological testing methods, determined relative toxicity values of major insect pests, tested a large number of new pesticides and prepared schedules for controlling the insect pests of brinjal, cotton, maize, mustard, okra etc. He was the first to point out the antifeedant properties of neem seed (*Margosa*). This attracted world wide attention and gave fillip to further work on neem seed in different countries.

For the last two decades, Dr. Jotwani was engaged in conducting and guiding research on insect pests of sorghum and millets and coordinated the work done at various research centres all over India. He was an authority on insect pests of sorghum and millets. His contribution to the control of sorghum shootfly by carbofuran seed treatment has been appreciated all over the world. He was often invited to attend various international symposia, seminars, deliver key-note addresses and to chair sessions. He visited various institutes in UK, USA, Japan, Thailand, Australia, Kenya, etc.

As a member of the post-graduate faculty of IARI, Dr. Jotwani was a very popular Professor. He was a person of practical intellectualism, mature experience, philosophical approach, responsive and responsible. He was articulate in expression both orally and in writing. He guided 14 Ph. D. and 2 M. Sc. students—all of whom are well placed in senior posts in India and abroad.

Dr. Jotwani has published about 200 scientific papers in various journals. He has also written chapters in several books besides being the author of three books. His book, *Sorghum Shootfly and its Control* is in great demand all over the world. His last book, (*Insects on Vegetables*) in joint-authorship with Dr. Dhama K. Butani is in press. Dr. Jotwani was also on the editorial boards of various entomological journals including ENTOMON.

Dr. Jotwani was life fellow of Entomological Society of India. He was General Secretary of the Society for 6 years and Vice and President for 2 years. As General Secretary he established the Society on a sound footing. He also compiled the first *Who is Who of the Members of Entomological Society, with A Directory of Pesticides Industry in India*.

Dr. Jotwani is survived by his wife Mrs. Gopi Jotwani and son Naresh Jotwani. His sudden and untimely demise is a great national loss especially to entomology.

May his soul rest in peace.

DHAMA K. BUTANI

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Books: NAYAR, K. K. (1973) *Elements in Insect Endocrinology*, Prentice Hall, India, 56 pp, *Chapter in book compiled and edited:* GILBERT, L. I. & D. S. KING (1973) Physiology of growth and development: Endocrine aspects, 249—370, in: *The Physiology of Insecta*, Vol. 1, 2nd ed. (ed. ROCKSTEIN, M.). Academic Press, New York & London.

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